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Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

A Tasmanian Stone Implement made from Bottle Glass

By

Norman B. Tindale

(Read 13th October, 1941)

Plate I

In 1938, Mr. F. D. Maning found a Tasmanian implement at Kempton, Tasmania, which had been made from the base of a glass bottle of old-fashioned type.

The interest of this particular specimen is in the form of which it has been made to take. It is an irregularly shaped notched scraper 6·5 cm. in diameter with three indentations, the arc of each of which has a radius of approximately 6 mm. The implement has had much use, and, owing to the relative softness of the material, the cutting edges show abrasion marks due to friction of the glass against the wood which it has been used to trim. The diameter of the notch seems to indicate that it was used for the preparation of a spear or a thin, club-like object. The abrasions also tend to suggest that part of the work must have been done at the extremity of some weapon, like a club, where the wood is tapering to a point or is rounded off.

The important abrasions appear principally on what corresponds to the inner face (or flake surface) of the implement, and examination of their directions gives rather definite indications of the likely method of holding and using the implement. Indeed, it suggests that the inner face was opposed to the work and that the implement was drawn towards the worker.

The few first-hand observations on record of the tool-using methods of the Tasmanians have indicated to us the likelihood that they used their stone implements without handles and without the aid of gum-hafting. The present example indicates that the stone itself was held very flatly against the material which was being worked, and that, in consequence, even notches which had become obtuse through constant re-sharpening could be used and be made to function efficiently.

Plate I, figs. 1 and 2, gives two views of the implement. Fig. 3 suggests the manner in which the implement was held while in use. The principal abrasive marks are indicated as they appear in association with two of the notches. The directions of abrasions suggest also that the implement was held at one time in the right hand and on another occasion in the left, the abrasions on the left-handed notch are rather less marked than those of the other. The third notch shows no signs of such abrasion, and may indeed have been freshly retrimmed just before the implement was abandoned.

Abrasions on the outer or worked surface seem to have been caused by rubbing, and suggest the possibility that the surface of the work may have been smoothed with this implement.

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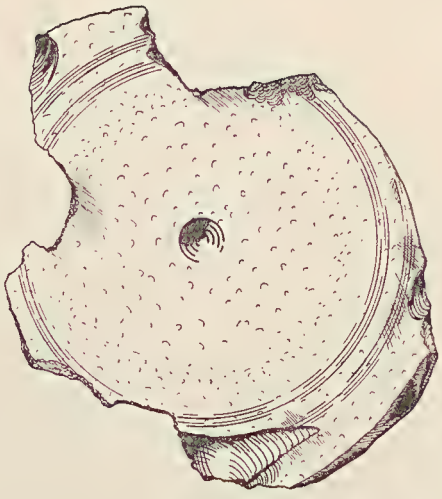
The implement is of well-defined Tasmanian type, and the material used dates the making of it to somewhere within the last two centuries. It would be of interest if it could be ascertained whether the glass is such as was used in English bottles of the early nineteenth century or whether it could be attributed to Dutch or other voyages of still earlier times.

The specimen has been kindly lent by Mr. F. D. Maning to the Tasmanian Museum at Hobart.

1



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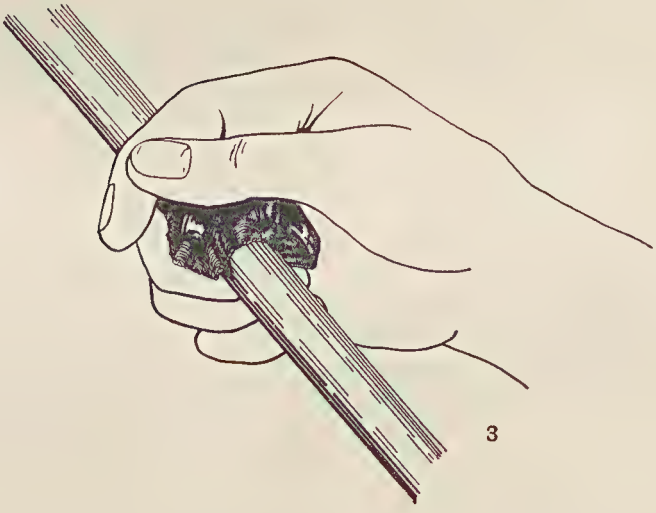

3

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Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

Some Tasmanian Palaeozoic Corals

By

Dorothy Hill

University of Queensland

(Read 13th October, 1941)

Plate II

Palaeozoic corals from several Tasmanian localities are described, including two new species, and the ages they indicate are discussed.

Upper Ordovician or Silurian

Limestone at the head of the Nelson R.

Plasmoporella sp. indicates that the age of this limestone is within the range of the genus—Upper Ordovician, Valentian, Niagaran.

Chudleigh Limestone, Liena, Mersey R.

Favistella cerioides sp. nov. resembles the Upper Silurian (Ludlow) *Favistella gothlandica* (Edwards and Haime) more closely than the Upper Ordovician species from North America. *Favosites marginatus* sp. nov. does not resemble closely any species described from the Silurian, but comparisons may be made with a rather imperfectly known form from the Upper Ordovician of North America. *Plasmoporella* cf. *convexotabulata* Kiaer is identical morphologically with the Upper Ordovician or Lower Silurian species from the Baltic and China. *Halysites ?chillagoensis* Etheridge has been recorded by Etheridge (1904, p. 38), but has not been re-studied. Thus the age of the Chudleigh limestone at Liena cannot yet be fixed more narrowly than Upper Ordovician or Silurian.

Silurian

Gordon R.

Hercophyllum shearsbyi (Sussmilch) and *Entelophyllum* sp. occur in the limestone on the Gordon R.; the former species occurs in beds which are Upper Wenlock or possibly Lower Ludlow at Yass, N.S.W., and the latter is very close to one species from these same Yass beds and to another from the Wenlock and Ludlow of Europe. The age indicated for this limestone on the Gordon R. is thus Upper Wenlock or Lower Ludlow.

SILURIAN OR POSSIBLY DEVONIAN

Blue-grey micaceous shale, yellow weathering

Pleurodictyum megastomum M'Coy occurs in this shale, in specimens without locality labels. It is known from the ?Lower Ludlow shale above the limestone near Bowning, N.S.W., and from the Lower Devonian of New Zealand, and thus indicates a similar age for the Tasmanian shale.

Zeehan

Pleurodictyum sp., which is probably *P. megastomum*, has been recorded from Zeehan (Etheridge, 1896, p. xlii, pl. i, fig. 1) and thus suggests that Ludlow or Lower Devonian beds occur here. From Zeehan I have an unidentifiable Streptelasmid, and, from the Montagu Mine, an internal mould of an unidentifiable *Favosites* sp., with an external mould of an unidentifiable solitary turbinate Rugose coral, in a blue-grey leached shale. Two moulds of similar solitary corals in blue-grey shale are from an unknown locality.

Point Hibbs

Heliophyllum ?chillagoense (Etheridge) resembles the cerioid Middle Devonian *H. tabulatum* (Quenstedt) from the Eifel, and *H. confluens* Hall from the U.S.A., and may thus indicate a Devonian age. However, the species described by Etheridge from Chillagoe, Queensland, was regarded by him as Silurian because *Halysites* occurred in the same great belt of limestone. But Weissermel (1939, p. 104) has lately described *Halysites* from the Lower Devonian (Gedinnian) of the Bosphorus. At Point Hibbs our specimen is associated with *Favosites ?bryani* Jones, a species which occurs elsewhere in the ?Lower and Middle Devonian of N.S.W. and the Lower Middle Devonian of Queensland. Although the Point Hibbs limestone has previously been regarded as Silurian, it is thus possible that it may be Devonian.

The Devonian *Favosites goldfussi* d'Orbigny is probably represented by three specimens whose matrix and preservation are similar to those from Point Hibbs, but which have no locality labels.

SYSTEMATIC DESCRIPTIONS

MADREPORARIA RUGOSA

Family ENTELOPHYLLIDAE Hill, 1940

Genus **Entelophyllum** Wedekind, 1927, p. 22

Entelophyllum, sp. (Pl. 2, figs. 1a, b)

Material. A fragment (F 4195, Australian Museum) embedded in a grey crinoidal limestone from the Gordon R., Tasmania. Silurian.

Description. The fragment is of two corallites, in part cylindrical and in part in contact and cerioid, the more complete corallite being 13 mm. in diameter in one section and 16 mm. in a section 13 mm. higher. There are 38 major septa which extend almost to the axis, and there rotate slightly, leaving an axial space about 2 mm. in diameter, and 38 minor septa extending just over half way to the axis. Both orders have a few carinae, either opposite or alternate, near the inner margin of the dissepimentarium, where they are also somewhat dilated. The

dissepiments are small, frequently geniculate in cross-section, and are rather globose in vertical section. The tabulae are incomplete, and consist of tabellae arranged in three series; those of the outermost and axial series are sagging, but the intermediate series is of highly arched plates capping one another.

Remarks. The specimen is closer to the genotype, which is from the Wenlock and Ludlow of Europe, than to any other of the described species, but it differs from the genotype in the slight dilatation and carination of the septa. It is quite close to *E. latum* Hill (1940, p. 413) from the Wenlock or Ludlow of Glenbower, N.S.W., but *E. latum*, like the genotype, is without carinae.

The age indicated is Wenlock or Ludlow.

The family and genus have already been discussed (Hill, 1940, p. 410; Hill and Jones, 1940, p. 188) in connection with their Australian representatives.

Family FAVISTELLIDAE Hill, 1939

Genus **Favistella** Hall, 1847, p. 275

Favistella cerioides, sp. nov. (Pl. 2, figs. 2a, b)

Holotype. F 5487 (Australian Museum 717), Chudleigh limestone, Liena, Mersey R., Tasmania. Upper Ordovician or ?Silurian. On the label the locality is written 'Siena'.

Diagnosis. Cerioid *Favistella* with corallites about 5 mm. in diameter, about 18 major septa, short minor septa, and slightly domed or horizontal, close tabulae.

Description. The corallum is cerioid; the corallites are unequal, varying from 1 mm. to 7 mm. in diameter, the average being about 5 mm. Increase is intermural. The common wall between two corallites may be 0·75 mm. thick. It contains a median dark line, and the stereozone on each side of this has been formed by the lateral dilatation of the bases of the septa. There are 18 smooth-sided and rather flexuous thin major septa, extending to or almost to the axis, and 18 very short lamellar minor septa alternating with them. There are no dissepiments. The tabulae are complete, slightly domed, the domes sometimes sagging at the axis, or horizontal, about 10 in 5 mm.

Remarks. The corallites are larger, and there are more septa than in the American Upper Ordovician species; but are similar to those of *Favistella gothlandica* (Edwards and Haime, 1851, pl. xiv, fig. 2) from the Silurian of Gotland. Our species differs from the latter however in the closer spacing of the tabulae. *F. kassariensis* (Dybowski; Weissermel), from the Silurian of the Baltic States, has very highly domed tabulae with upturned edges, and thus differs from our species. Lindstrom (1888) lists *Columnaria gothlandica* Edwards and Haime from *f*, beds equivalent to the Lower Ludlow.

The family and genus have already been discussed (Hill, 1939, p. 241) in connection with their Australian representatives.

Family HELIOPHYLLIDAE

Typical Genus: **Heliophyllum** Hall MS. in Dana

Rugose corals in which the septa are carinate, with vertical carinae either opposite or alternate; the septa are long, and extend unequally and rather flexuously towards the axis, sometimes being thickened in the tabularium; the tabular floors are horizontal or slightly concave or domed, and are usually of tabellae; the dissepiments are small and globose.

Remarks. This family is represented in the Couvinian of the Eifel by *Ceriophyllum* Wedekind, which (see below) is probably, a synonym of *Heliophyllum*, and in the Hamilton of U.S.A. and Canada by *Heliophyllum* Hall. The forms placed in *Ceriophyllum* by Wedekind differ from *Heliophyllum halli* in having their septal carinae alternate on each side of the septum instead of opposite, and in having the structure of their tabularia rather more open, with the tabular floors predominately domed, instead of almost equally horizontal or concave or domed. The family may have been derived from the Silurian *Entelophyllidae*. Both have carinate septa and a wide tabularium, but in the *Entelophyllidae* the tabular floors are almost constantly domed, with axial insinkings, while in the *Heliophyllidae* the tabular floors are less regular and may be domed or sagging. Cross-bar carinae are common in the *Heliophyllidae*, but are not known in the *Entelophyllidae*.

Genus **Heliophyllum** Hall MS. in Dana

Heliophyllum Hall MS in Dana, 1848, p. 356; see Lang, Smith and Thomas, 1940, p. 66.
Ceriophyllum as *Keriophyllum* (sic) Wedekind, 1923, pp. 27, 34; genotype, *C. heiligensteini* Wedekind, 1923, p. 34; text-figs. 3a, b on p. 27. Lower Middle Devonian, Heiligenstein, the Eifel, Germany.

Genotype. Heliophyllum halli Edwards and Haime, 1850, p. lxix (see Lang, Smith and Thomas, *loc. cit.*), Middle Devonian, Hamilton group: Moscow, York and Seneca Lake, New York, U.S.A.

Diagnosis. Simple or compound Rugosa with long septa with vertical carinae either opposite or alternate, with major septa extending flexuously in the tabularium almost to the axis, and with small dissepiments, and flat, gently domed or sometimes also slightly concave, tabulae.

See remarks under family.

Heliophyllum chillagoense (Etheridge).

Cyathophyllum chillagoensis Etheridge, 1911, p. 4, pl. D, figs. 1, 2, Silurian [?], Chillagoe, Queensland.

Diagnosis. Cerioid *Heliophyllum* with alternate carinae and close, domed tabulae.

Heliophyllum ?chillagoense (Etheridge). (Pl. 2, figs. 3a, b)

Material. One specimen in the collection of the Geological Survey of Tasmania, from Point Hibbs.

Description. The corallum is cerioid, the corallites being unequal, up to 18 mm. in diameter, the average being about 15 mm. New corallites probably arise by peripheral increase, as they tend to have circular walls. There are about 24 major septa extending almost to the axis, slightly flexuous in the tabularium, and 24 minor septa extending two-thirds of the way to the axis; both orders may be dilated in the dissepimentarium, and both are carinate with carinae perpendicular to the inclination of the dissepiments, and alternate on either side of the septum. The dissepiments are small in the inner parts, but larger towards the periphery; their inclination is towards the axis in the inner parts, but gently towards the periphery in the peripheral region. The area of divergence is also shown in the traces of the septalcarinae in median vertical section of the corallite. The tabulae are incomplete and very close, the tabular floors being horizontal or slightly domed.

Remarks. The specimen appears to differ from *Heliophyllum chillagoense* only in having thicker septa, and may indeed belong to this species. The North Queensland holotype has been regarded as Silurian, because of the occurrence of *Halysites* in the same great limestone belt. But Weissermel (1939, p. 100) has described

species of *Halysites* from the Gedinnian (Lower Devonian) of the Bosphorus. Because of this Chillagoe anomaly, the Tasmanian specimen cannot be regarded as reliable as an indicator of age. *Billingsastraea billingsi nevadensis* Stumm (1937, pl. 55, fig. 9), from the Lower Middle Devonian of Nevada, U.S.A., differs from our species in being astraeoid, but its internal structure is very similar. In its alternate carinae our specimen resembles the European Couvinian *H. tabulatum* (Quenstedt) rather than the Hamilton American *H. confluens* Hall.

Family PYCNACTIDAE Hill, 1940

Genus **Hercophyllum** Jones, 1936b, p. 53

Hercophyllum shearsbyi (Sussmilch). (Pl. 2, fig. 4)

Cyathophyllum shearsbyi Sussmilch (ex Etheridge MS), 1914, fig. 143, facing p. 44. Limestone Ck., Bowning District. Silurian.

Hercophyllum shearsbyi (Sussmilch) Jones, 1936*b*, p. 54, pl. v, figs. 1a-g; pl. vi, figs. 1a-g; pl. vii, figs. 1h, i; 2.

Remarks. A partly beekitised specimen (F 4211, Australian Museum), from the Gordon R., is referable to this species, which with its genus and family has recently been fully discussed (Hill, 1940, p. 401).

Unidentifiable Rugosa

External moulds

A fragment 20 x 20 mm. of an external mould of a solitary, turbinate Rugose coral, showed well-marked longitudinal striation and transverse growth rings. It was preserved in a leached blue-grey sandy shale from the Montagu Mine, Zeehan.

Two other fragments, G1 and G2 of similar external moulds, in a blue-grey shale one 30 x 30 mm., of solitary, turbinate Rugose corals, also showing marked longitudinal striation, are without locality labels.

Streptelasmid

A thin section was made of a solitary, trochoid Rugose coral softened by weathering, in a blue-grey shale from Zeehan; it showed 30 major septa with 30 alternating ragged minor septa of unequal length, and no dissepiments, at a diameter of about 13 mm. The corallum was rather compressed (F 37801, Australian Museum). It is probably a Streptelasmid, and may be the species giving the moulds described above. It is no safe indication of age, Streptelasmids being known from the Upper Ordovician to the Middle Devonian.

Madreporaria Tabulata

Genus **Pleurodictyum** Goldfuss

Pleurodictyum Goldfuss, 1829, p. 113

Genoholotype. P. problematicum Goldfuss, 1829, p. 113, pl. xxxviii, figs. 18a-g. Lower Devonian, Eifel District and Nassau, Germany.

Diagnosis. Massive corals with thick walls pierced by mural pores, and with septa represented by low ridges with one or more rows of low spines; the calical floors are frequently furnished with small spines. The genotype usually has a worm cast through it.

Remarks. The genotype is known only in casts in sandstone; and, from the topotypes before me, I cannot be sure that tabulae were present. Lang, Smith, and Thomas (1940, p. 102) have considered with Hall and others that *Michelinia* de Koninck and its subgenera are synonymous with *Pleurodictyum*, and these genera are tabulate. The distinction between them and thick-walled *Favosites* has not yet been made clear, and the whole group is in need of revision. Nicholson's (1879, p. 149) researches on an American species he regarded as a *Pleurodictyum* with its own tissues preserved, showed that it possessed intramural canals in addition to mural pores. He observed that intramural canals were not present in *Favosites*, but were known in *Columnopora* and *Lyopora*. The internal moulds of *P. problematicum* which I have studied, however, give no indication of the presence of intramural canals.

Pleurodictyum megastomum M'Coy. (Pl. 2, fig. 5)

?Pleurodictyum megastomum M'Coy, 1867, Upper Silurian, Upper Yarra District, Victoria. *Nomen nudum.*

Pleurodictyum megastomum Dun, Chapman, 1921, p. 216, pl. ix, figs. 4-6: *quo vide* for list of records and localities.

Diagnosis. Low, hemispherical or explanate *Pleurodictyum* with corallites up to 10 mm. in diameter, average about 6 mm., each with about 25 low septal ridges studded with one or more series of low spines; the calical floors have irregularly arranged low spines.

Remarks. This Australian Upper Silurian (Ludlow?) and New Zealand Lower Devonian species is known only from moulds. It has already been adequately described, particularly by Foerste (1888, p. 132, pl. xiii, fig. 22) and Shirley (1938, *Q.J.G.S.*, p. 463). Two internal moulds in a yellow-weathering blue-grey shale with mica are in the collection sent from Tasmania, but their locality is not stated. They are labelled S10 and 7 11. One is 40 mm. in diameter and the other 30. The smaller shows the septal ornament well, and is figured herein (pl. 2, fig. 5). They indicate the Upper Silurian or the Lower Devonian. A third specimen in a grey-blue shale, also without locality, shows two poorly preserved specimens with corallites the same size as the others. The specimen figured from Zeehan by Etheridge (1896, pl. i, fig. 1) might well be this species.

Family FAVOSITIDAE

Genus **Favosites** Lamarck

Favosites bryani Jones

Favosites bryani Jones, 1937, p. 96, pl. xv, figs. 3-6, Lower Middle Devonian, Taemas; Hill and Jones, 1940, p. 190, pl. v, figs. 2a, b, ?Lower Devonian, Molong District.

Diagnosis. *Favosites* with corallites about 1 mm. in diameter, moderately thick-walled and polyhedric, with long, slender, sharply-pointed septal spines, sometimes opposite, one row of circular mural pores, and fairly numerous tabulae, which are mostly complete.

Remarks. A specimen (pl. 2, fig. 6) from Point Hibbs appears to belong to this species; its spines are, however, more horizontal than inclined. It suggests a Lower or Middle Devonian age for the Point Hibbs beds.

Favosites goldfussi d'Orbigny

Favosites goldfussi d'Orbigny, Jones, 1936*a*, p. 19; Devonian, the Eifel.

Diagnosis. *Favosites* with corallites 2-2·5 mm. in diameter, with moderately thick walls, and numerous blunt septal spines with a slight upward inclination, sporadically developed; with round mural pores, in two or three alternating rows on each face; and with numerous tabulae, 3 or 4 in 3 mm.

Remarks. Three specimens, one pyriform (pl. 2, fig. 7), have matrix and preservation similar to that of *F. ?bryani* from Point Hibbs, although their labels gave no locality except Tasmania. They are considerably altered, but agree fairly well with the Devonian *F. goldfussi*, although there are points of resemblance also to the Silurian *F. gothlandicus*. Lecompte (1939, p. 83) has recently given details of European members of *F. goldfussi*, and Hill and Jones (1940, p. 191) of some Australian members.

Favosites marginatus sp. nov. (Pl. 2, figs. 8a, b)

Material. Two specimens (F 5486 C6, and F 5486 C3, Australian Museum) from the Chudleigh Limestone, Liena, Mersey R., of which the former is the holotype. Upper Ordovician or Silurian.

Diagnosis. Pyriform *Favosites* with corallites 0·5 to 3 mm. in diameter and moderately thick walls crenulate in transverse section, with short horizontal septal spines, and with rather rare pores at the margins of the septal faces.

Description. The corallum is pyriform, the larger fragment being 7 cm. tall and 4 cm. wide. The corallites vary in diameter from 0·05 mm. to over 3 mm., the smaller corallites occurring at the angles of the larger. The walls of each corallite are separated from neighbours by a median dark line, and the common wall is about 0·25 mm. thick. In transverse section the walls are usually crenulate, but not in vertical section; numerous short, sharp, horizontal spines are present, a vertical series arising from each projecting crenulation; it is possible that each series has a narrow lamellar base. Mural pores appear to be confined to the margins of the faces near but not through the angles; they are slightly oval, and are about 0·25 mm. wide, and two, but not three, corallites intercommunicate by each. The tabulae are horizontal or slightly domed or sagging, and are rather distant, about 10 in 10 mm.

Remarks. The crenulation of the walls and the position of the pores distinguishes this from all other species. The spines are not unlike those of *Columnaria? halli* Nicholson of Lambe (1901, pl. vi, fig. 2a) from the Upper Ordovician of Canada; and Nicholson (1879, p. 201) considered that mural pores might be present in his species.

MADREPORARIA HELIOLITIDA Jones and Hill, 1940

Genus **Plasmoporella** Kiaer

Plasmoporella Kiaer, 1899, p. 34.

Camptolithus Lindstrom, 1899, p. 99, genotype, *Lyellia papillata* Rominger, 1876, Silurian, Niagaran: Point Detour, Lake Huron, Michigan, U.S.A.

Genotype. *P. convexotabulata* forma *typica* Kiaer, 1899, p. 35, pl. v, figs. 9-11. Silurian (?Ordovician), Étage 5 of Kiaer, Gasteropodkalk: Stavnaestangen and other localities, Norway.

Diagnosis. Heliolitida in which the reticulum consists of globose testae; with domed tabulae, complete or incomplete; and with discrete trabeculae throughout the tissue.

Remarks. The genus differs from *Propora* only in the tabulae, which are domed and complete or incomplete, in contrast to the complete, horizontal or sagging plates in *Propora*. It occurs in Étage 5 in Norway (Upper Ordovician or Lower Silurian), in the Lower Silurian of China (Yoh, 1932, p. 69), and in the Niagaran of U.S.A. (Lindstrom, 1899, p. 101).

Plasmoporella cf. **convexotabulata** Kiaer. (Pl. 2, fig. 9)

Material. One thin section cut from F 5486 C3 (Australian Museum), from the Chudleigh Limestone, Liena, Mersey R., Tasmania. Upper Ordovician or Silurian.

Diagnosis. Plasmoporella with moderately long septa, loose tissue and complete, distant, domed tabulae.

Remarks. The one thin section is almost identical with the typical variety of the genotype from the Upper Ordovician or Lower Silurian of Norway.

Plasmoporella sp. (Pl. 2, figs. 10a, b)

Material. One fragment from the limestone at the head of the Nelson R., Tasmania, collected by W. R. Browne. Upper Ordovician or Silurian.

Diagnosis. Plasmoporella in which the domed tabular floors are formed by numerous very small, close tabellae.

Description. The tabularia are about 1 mm. in diameter, and are distant about 1 mm. or less. The twelve septa in each tabularium are rather thick, extending from one-third to one-half of the way to the axis of each tabularium, and projecting into the reticulum for an equal distance. There are numerous discrete trabeculae based on the testae, and some on the tabellae. The tabular floors are domed, and the tabellae are very numerous, small and close. The testae are also numerous and small, and are highly globose.

Remarks. The fragment differs from the known species in the character of the tabellae, which are smaller, closer, and more globose than in the others, and in the slightly greater length of the septa. It indicates for the limestone containing it an age covered by the range of the genus, which is from the Étage 5 of Norway (Upper Ordovician or Lower Silurian), to the Niagaran (Wenlock) of America.

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Plate II

All figures x2 diameters approximately, unless otherwise indicated.

Fig. 1.—*Entelophyllum* sp. F 4195, Australian Museum, from a grey crinoidal limestone on the Gordon R., Silurian. *a*, transverse and *b*, vertical section.

Fig. 2.—*Favistella cerioides* sp. nov. Holotype, F 5487, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian. *a*, transverse and *b*, vertical section.

Fig. 3.—*Heliophyllum ?chillagoense* (Etheridge) Tasmanian Geological Survey Coll., Point Hibbs, ?Devonian. *a*, transverse and *b*, vertical section.

Fig. 4.—*Hercophyllum shearsbyi* (Sussmilch). F 4211, Australian Museum, limestone on the Gordon R., Wenlock or Ludlow. Transverse section.

Fig. 5.—*Pleurodictyum megastomum* M'Coy. 7 11, Tasmanian Geological Survey Coll., Tasmania. Internal mould, x1·5 diameters.

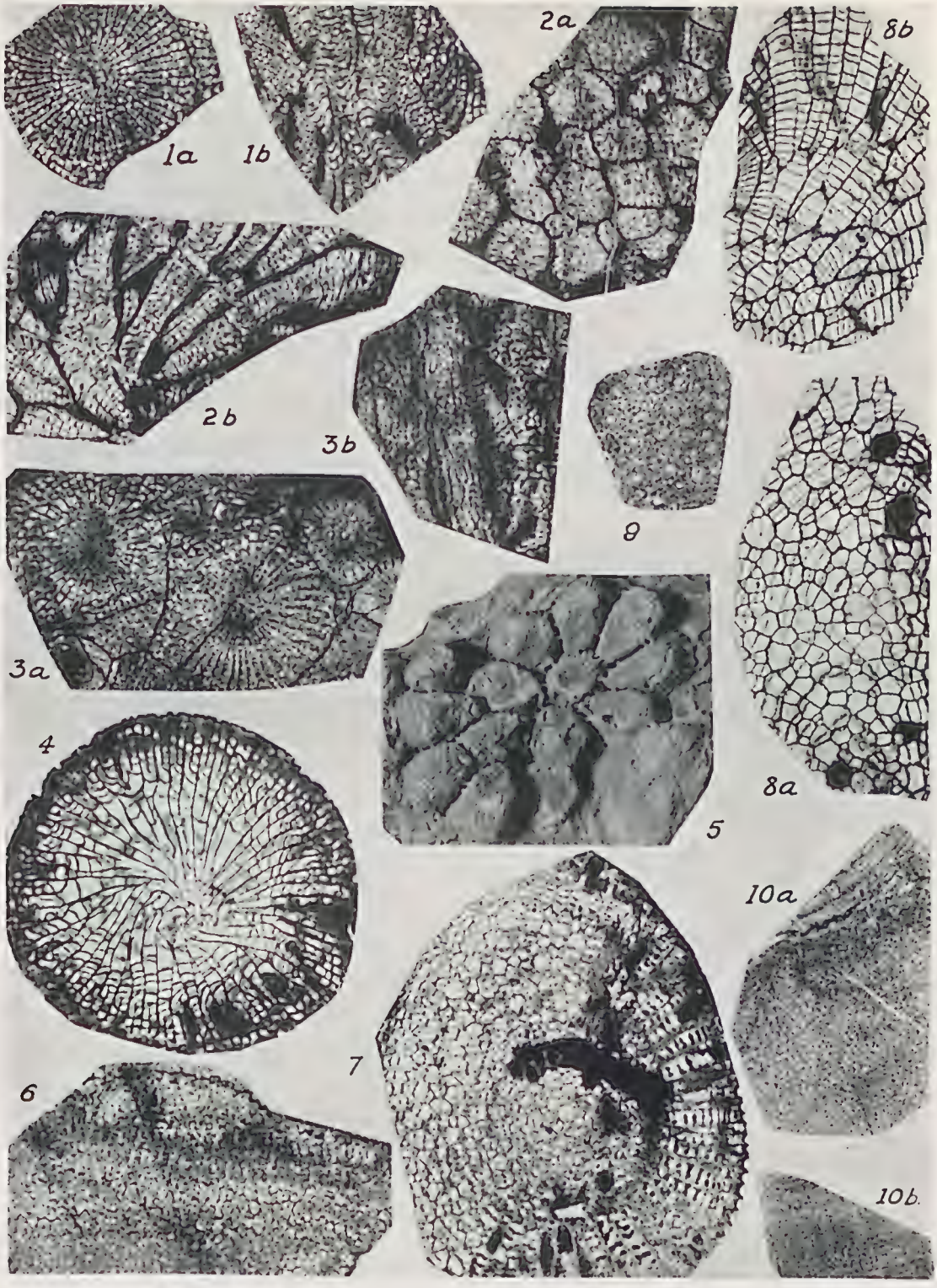
Fig. 6.—*Favosites ?bryani* Jones. Tasmanian Geological Survey Coll. Point Hibbs, ?Devonian. Section.

Fig. 7.—*Favosites ?goldfussi* d'Orbigny. Tasmanian Geological Survey Collection, Tasmania. ?Devonian. Section. x1·6 diameters.

Fig. 8.—*Favosites marginatus* sp. nov. Holotype. F 5486 C6, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian. *a*, transverse, *b*, vertical section.

Fig. 9.—*Plasmoporella* cf. *convexotabulata* Kiaer. Thin section from F 5486 C3, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian.

Fig. 10.—*Plasmoporella* sp. W. R. Browne Coll., limestone at the head of the Nelson R., Upper Ordovician or Silurian. *a*, transverse and *b*, vertical section.


1a
1b
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10b

NATIONAL MUSEUM OF VICTORIA

Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

The Grapsid and Ocypodid Crabs of Tasmania

By

M. W. F. Tweedie

Raffles Museum, Singapore

(Read 13th October, 1941)

During a visit to Tasmania lasting from December, 1940, to April, 1941, I made a small collection of shore crabs, chiefly from the neighbourhood of Hobart, which included all but two of the species recorded from the island of the families indicated in the title (1).

Access to the collections and library at the Australian Museum, Sydney, and working facilities very kindly granted by the Director, Dr. A. B. Walkom, have enabled me to prepare this paper. My thanks are also due to Dr. J. Pearson for the loan of collecting materials and for permission to use the Royal Society's library at Hobart.

No new or rare species are recorded, and the paper is intended rather to assist identification of the Tasmanian species of these families of crabs than as a contribution to systematic carcinology. Those unfamiliar with the morphological terms used will find a clear and complete account of them in Hale, 1927 a.

The drawings are traced from photographs, and in some the carapace is slightly foreshortened; no attempt has been made to reproduce the colours or markings.

Family GRAPSIDAE

Typically the crabs of this family have the carapace flattened and more or less quadrate. The front is broad, and the orbits are at or near the antero-lateral angles, the eye-stalks being short and thick. There is always a distinct gap between the external maxillipeds.

Most of the Grapsids inhabit the seashore and the margins and flats of tidal rivers, some species running actively over the rocks, others living in burrows or under stones and driftwood. Some are more or less predatory, but they exist chiefly by scavenging.

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(1) The Soldier Crab, *Mictyris platycheles*, is excluded from this account as the genus, formerly classified with the Ocypodidae, is now regarded as constituting a separate family. A very complete account of the species of the genus is given by McNeill (1926).

KEY TO THE SUBFAMILIES.

1. The first antennae fold beneath the front in the usual manner, and are not then visible from above ....

and prominent, and its upper surface is coarsely granular. The epigastric region, behind the front, is studded with transverse tubercles. The rest of the carapace is smooth with a number of parallel, obliquely transverse, raised lines on each branchial region. The chelipeds are large in the male; with increasing age and size they become relatively more massive, and the closed fingers gape more and more widely. The inner edge of the arm is expanded to form a toothed laminar process, and there is a tooth at the inner angle of the wrist. The chelae are smooth with some tubercles on the upper part and a ridge on the lower part of the palm, which runs onto the immovable finger; the tubercles are fewer and the ridge fainter in older specimens. The meri of the walking legs are flattened and expanded, and carry an anterior subdistal spine and two or three teeth at the posterior distal margin, except in the last pair, where the teeth are at most faintly indicated. Each dactylus carries four rows of strong spines. Large specimens are as much as 70 mm. in carapace breadth.

Colour. Variable, ranging from dark grey to various shades of red and yellow; the claws are blue or purple.

Distribution. Southern Australia, ranging north as far as Rockhampton on the east coast, New Zealand, and other South Pacific islands and West Coast of South America. Specimens from Moutouard Island in the Bass Strait are in the Australian Museum collection, and the species most probably occurs in Tasmania.

Remarks. This crab is found on exposed, rocky coasts, and runs with great speed and agility over the rocks.

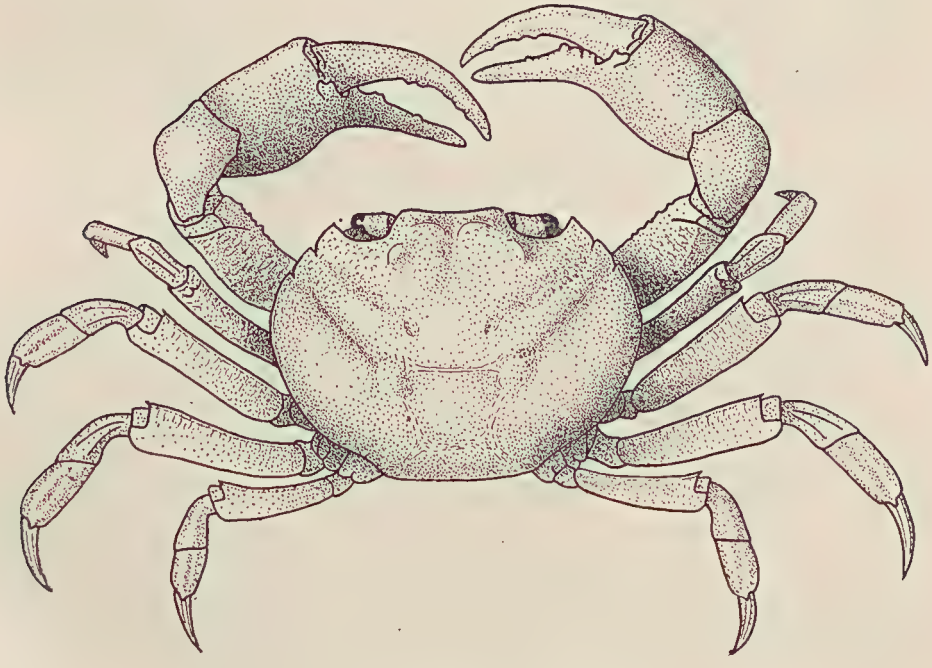

FIG. 2.—*Brachynotus octodentatus*, ♂

Subfamily VARUNINAE

Two species of one genus are found in Tasmania.

Brachynotus octodentatus (Milne Edwards). Fig. 2

Tesch, 1918, p. 106.
Hale, 1927 a, p. 182.
Montgomery, 1931, p. 452 *(Leptograpsodes webhaysi).*
Balss, 1935, p. 142.

Material. I collected none myself, but two small specimens from Hawley Beach, Devonport (2.5.38, Coll.A.L.W.), are in the collection of the Hobart Museum.

Description. This is a large species, reaching 60 mm. in carapace breadth. The carapace is flattened, but the branchial regions are convex and the post-frontal tubercles distinct. Its anterior and lateral parts are granulate in small, less so in large individuals. The lateral margins are arched, with three teeth behind the outer orbital angles, which decrease in size posteriorly, the last being small and obscure. A deep groove, representing the lateral part of the cervical groove, runs obliquely backwards on each side of the carapace from a point near the second of these teeth. The edge of the front is faintly emarginate. In the female the chelipeds are small and the fingers slender and scarcely gaping when closed. In the male they become larger and increasingly robust with age, the arms (meri) projecting far beyond the edge of the carapace; at the same time the immovable fingers become more strongly bent downwards at an angle from the palm and the dactyli more curved, so that in large males the fingers gape widely when closed. The chelae are smooth, with a few scattered granules on the inner surface in males. The fingers are irregularly dentate along their biting edges, one tooth near the base of the immovable finger being larger than the rest and often itself denticulate.

Colour. Olivaceous mottled or spotted with dark brown.

Distribution. Tasmania and the southern half of Australia. Haswell's record from the north coast of Tasmania is incorrect (see Hale, 1927 b. p. 313), but the Hobart Museum specimens re-establish it in the fauna of the Island. It occurs also on King Island.

Remarks. I agree with Balss that the characters described by Montgomery for *Leptograpsodes webhaysi* are not sufficient to distinguish it from the present species.

B. octodentatus occurs on rocky coasts in rock crevices, under stones, etc. The old males are found living singly in burrows.

Brachynotus spinosus (Milne Edwards). Fig. 3

Hale, 1927 a, p. 184; 1927 b, p. 312 *(Eriocheir spinosus).*

Material. Specimens from the shore at Brown's River, near Hobart, and from the estuary of the Carlton River.

Description. A small species, not often exceeding 20 mm. in carapace breadth. The carapace is flattened, and its surface is uneven, the regional boundaries, especially the cervical groove, being well defined. There are three teeth on the lateral margins, behind each outer orbital angle, which usually diminish in size posteriorly, but the second may be the smallest. The greatest breadth of the carapace is at the level of the hindmost of these teeth. Its surface is finely granular anteriorly and smooth elsewhere. A raised line runs back from the posterior lateral tooth to a point over the base of the last leg, cutting off a distinct posterior branchial facet. The front is broad and emarginate in the middle. The corneae of the eyes are peculiar in being black spotted with white. The

male chelipeds are not much enlarged. They are quite smooth, and the fingers scarcely gape when closed. In the basal part of the cleft of the fingers of each chela there is a patch of short, matted hairs. The chelae of the female are more slender and lack this patch of hair. The walking legs are somewhat flattened, and there is an anterior sub-distal spine on the merus of each. In the male there is a tuft of short fur on the distal half of the hinder edge of the propodus of the first and second legs, which is absent in the female or at most faintly indicated on the first leg only. My largest specimen, a female, is 21 mm. in carapace breadth.

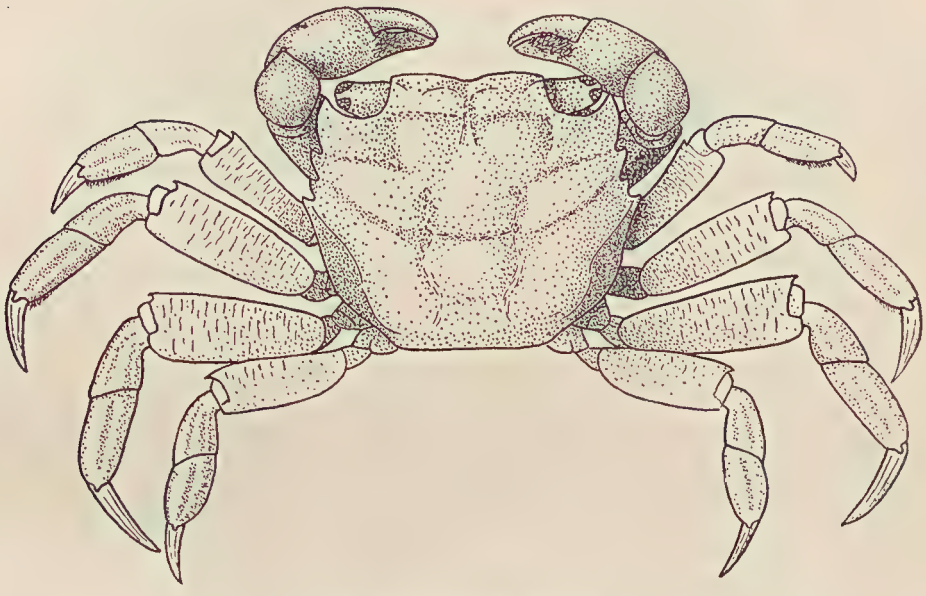

FIG. 3.—*Brachynotus spinosus*, ♂

Colour. Dull green or brown with or without white markings, which may be so extensive as largely or wholly to replace the darker colour.

Distribution. Originally described from Australia, this species appears to be confined there to the southern part of the continent and Tasmania. It would thus seem to be a cold water form, and records in the older literature from the tropical islands of Vanicoro and Upolu are rather hard to explain and, in my opinion, require confirmation.

Remarks. Hale placed this species in *Eriocheir*, a genus that includes the well-known Mitten Crab, *E. japonicus*, and is otherwise confined to north China and Japan. The front in *Eriocheir* is typically much narrower than in *B. spinosus*, and the presence of hair on the fingers of the male is characteristic of a number of Varunine genera in addition to *Eriocheir*.

The species was found commonly under stones and driftwood, especially the latter, on the sandy and muddy shores of the Carlton estuary. At Brown's River specimens were found in rock pools, and most of them were much paler in colour than those from the Carlton. Both in maximum and average size, the females collected were larger than the males.

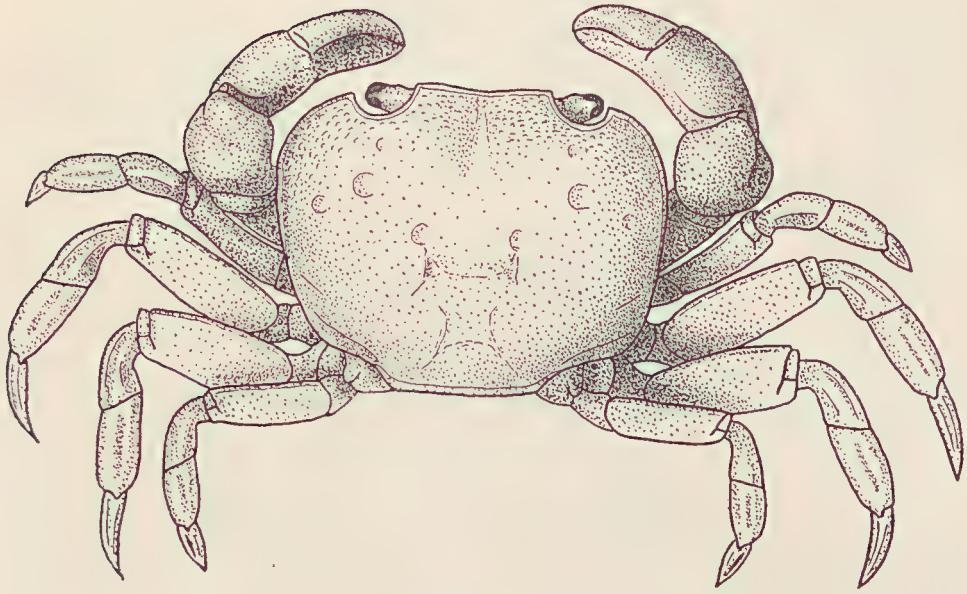

FIG. 4.—*Cyclograpsus audouinii*, ♂

Subfamily SESARMINAE

Four Tasmanian species included in three genera.

KEY TO THE GENERA (after HALE, 1927 a, p. 175).

1. Antero-lateral margins cut into teeth 2
   Antero-lateral margins not cut into teeth .... CYCLOGRAPSUS
2. Body thick and front very declivous. Last abdominal segment of female less than twice as wide as long .... HELICE
   Body more depressed with front not markedly declivous. Last abdominal segment of female at least twice as wide as long .... PARAGRAPSUS

Cyclograpsus audouinii (Milne Edwards). Fig. 4

Hale, 1927 a, p. 176.
Balss, 1935, p. 142 *(C. punctatus audouinii)*.

Material. Specimens from the shore near Brown's River.

Description. The carapace is smooth and flat with some symmetrically placed shallow pits, better developed in adults than in juveniles, and with the frontal, orbital, and hepatic regions finely granulate. The gastric, cardiac, and intestinal regions are bounded by ill-defined wrinkled depressions. The frontal, orbital, and lateral borders are raised and finely beaded, the latter quite entire. The front is broad and faintly emarginate in the middle. The chelipeds of the adult male are large, the chelae smooth externally, the inner surface bearing a granular ridge. The largest specimen collected, a male, measured 32 mm. in carapace breadth.

Colour. The anterior part of the carapace is dark purple, giving place to pale greenish posteriorly through an intermediate zone irregularly blotched with both colours. The purple may prevail almost entirely at the expense of the green, but the shallow pits are generally pale coloured. The wrists and upper margins of the chelae are purple; the rest of the palm and the fingers white.

Distribution. The whole of southern Australia, Tasmania, and New Zealand. Although it is most typically a cold water form, it has been recorded from the tropical Pacific and New Guinea.

Remarks. I found this crab only on stony beaches, quite devoid of mud and sand, below cliffs and headlands, living underneath the larger stones.

FIG. 5.—*Helice haswellianus*, ♂

Helice haswellianus (Whitelegge). Fig. 5

Haswell, 1882, p. 106 (*Chasmagnathus convexus*, nec *C. convexus* de Haan).
Whitelegge, 1890, p. 229 *(Chasmagnathus haswellianus).*
Hale, 1927 a, p. 177.

Material. Specimens from Brown's River, near Hobart, burrowing in mud in company with *Heloecius cordiformis*; these were compared with the type of "*C. convexus*" Haswell in the Australian Museum.

Description. The carapace is convex in both directions, strongly so fore and aft, the front being so steeply deflexed that its edge is scarcely visible in dorsal view. Its surface is everywhere smooth and polished, the inter-regional grooves shallow and indistinct. The lateral margins are convex with a small incision behind each outer orbital angle. Viewed from the front the frontal margin appears obscurely quadrilobate. The chelae are fairly large and quite smooth externally in the adult male, with a granular swelling on the inner surface and bordered below by a distinct ridge; those of the female are small and finely granular externally. The walking legs are slender, more so than in any of the other Tasmanian Sesarminae.

Adult specimens measure between 25 and 30 mm. in carapace breadth.

Colour. The carapace is dark olive or slate colour with some paler, slightly depressed spots and occasionally some lighter markings anteriorly. The legs, wrists and upper margins of the chelae are like the carapace, the outer surface of the chelae yellow.

Distribution. South-eastern Australia and Tasmania.

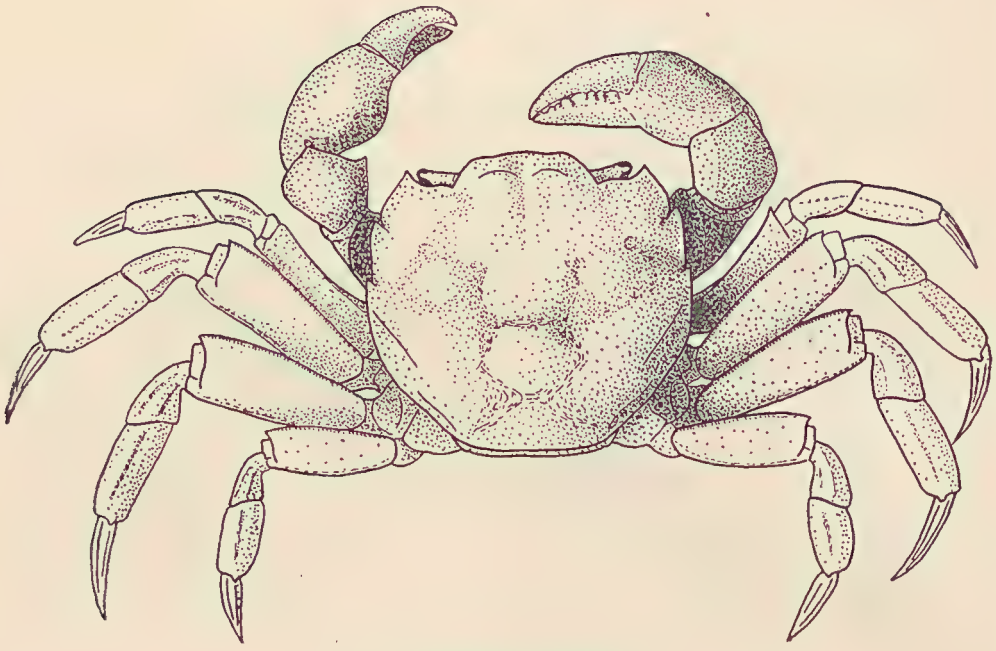

FIG. 6.—*Paragrapsus gaimardii*, ♂

Paragrapsus gaimardii (Milne Edwards). Fig. 6

Haswell, 1882, p. 105.
Tesch, 1918, p. 119 *(Helice gaimardi)*.
Hale, 1927 a, p. 179.

Material. Specimens from Brown's River and Sandy Bay, Hobart.

Description. The carapace is about as broad as long, moderately convex in both directions and everywhere finely granulate. The lateral margins carry two teeth behind the outer orbital angle. There is an oblique granular ridge on each branchial region and another shorter one over the bases of the two last pairs of legs. The front is prominent; its edge is turned up as are those of the lateral margins in front of the posterior teeth. The orbital margins are distinctly angulate where they join the frontal margin near the bases of the eye-stalks. The chelae of the male are fairly large, finely rugose externally, and granular on the inner surface. The biting edges of the fingers do not gape, and are beset with closely and evenly spaced rounded teeth. Those of the female are small with a granular ridge running along the lower part of the outer surface of the palm and onto the immovable finger. The walking legs are broad and flattened. In the adult male the suture between the first and second sternal plates on each side of the abdomen is marked by a prominent ridge.

Adult males measure 40 to 50 mm. in carapace breadth.

Colour. The carapace is greenish above, spotted with dark red; posteriorly the spots are distinct, but in front of the cervical groove the red colour becomes finely diffuse or runs together to form blotches. Light coloured depressions are usually present disposed much as in *C. audouinii*. The ground colour of the legs and chelipeds is lighter and the red spots very distinct; outwardly the chelae are yellowish and unmarked.

Distribution. Tasmania, Victoria, and South Australia.

Remarks. This is the commonest shore crab in the neighbourhood of Hobart. A large stone turned over on any foreshore where the sand contains an admixture of mud often reveals a score or more, which immediately scramble for shelter beneath the overturned stone or even under the feet of the collector; it is found also in sandy and muddy lagoons where there are no stones. This species and *Cyclograpsus audouinii* are never found together. The latter inhabits only the clean, stony beaches, while no surroundings seem to be too dirty for *P. gaimardii.*

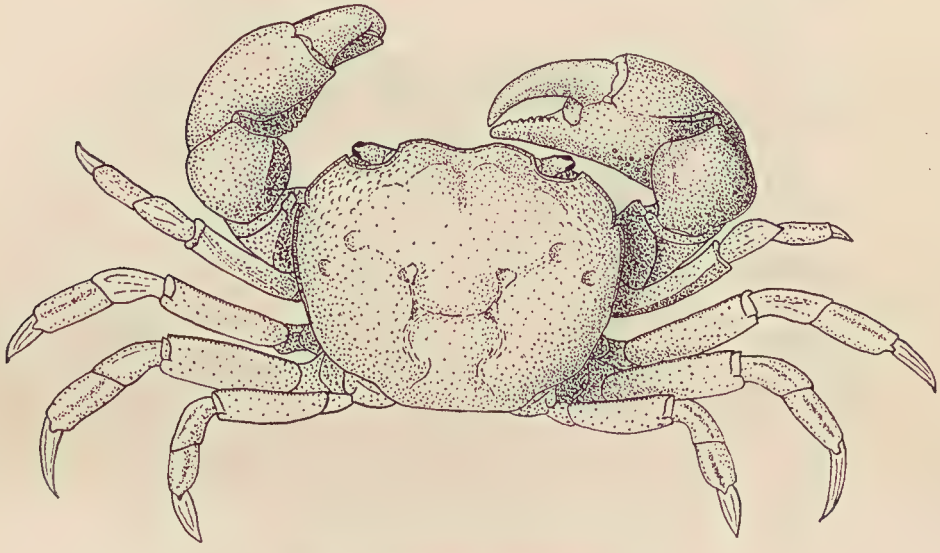

FIG. 7.—*Paragrapsus quadridentatus*, ♂

Paragrapsus quadridentatus (Milne Edwards). Fig. 7

Haswell, 1882, p. 105.
Tesch, 1918, p. 125.

Material. Specimens from Brown's River, near Hobart.

Description. The carapace is broader than long, flattened transversely, smooth, and polished except on the frontal, orbital, and hepatic regions, where it is finely granular. A number of shallow pits is disposed on the carapace as in *C. audouinii*, and the gastric, cardiac, and intestinal regions are bordered by wrinkled depressions as in that species, but rather more distinctly. The lateral margins have only one tooth behind the outer orbital angle. The edge of the front is distinctly excavated in the middle. The chelae of the male are very large and swollen, the outer surface smooth, a short row of granules on the inner surface of the palm. The fingers gape when closed and have small, unequal teeth on their biting edges; a large, fleshy protuberance fills the proximal part of the space between the gaping fingers. The female chelae are small and ridged as in *P. gaimardii.* The walking legs are fairly slender, not expanded and flattened as in that species.

Colour. The carapace is greenish grey spotted with reddish brown, the spots being much more scattered and less numerous than in *P. gaimardii*. The legs and the upper parts of the chelipeds are the same colour but not spotted, the colour fading to yellowish white on the outside of the chelae.

Distribution. Tasmania and Victoria.

Remarks. This species has many points of resemblance to *Cyclograpsus audouinii* and is probably more closely related to that species than to *P. gaimardii*. Our present somewhat artificial conception of the two genera refers it to *Paragrapsus* on account of the dentate antero-lateral borders.

In the original description the front was described as almost straight; both Haswell and Tesch (ll.c.) have copied this observation, but it is only true of juvenile specimens; in the adult the front is distinctly excavated in the middle.

FIG. 8.—*Plagusia capensis*, anterior part of carapace.

Subfamily PLAGUSIINAE

A single Tasmanian species.

Plagusia capensis (de Haan). Fig. 8

Tesch, 1918, p. 129.
Hale, 1927 a, p. 185 *(P. chabrus)*.
Balss, 1935, p. 143.

Material. Not collected, but the species is well known from Tasmania and the Hobart Museum possesses specimens.

Decription. The presence of two deep clefts in the front, in which the first antennae are visible, make this crab unmistakable. The carapace is flat and everywhere covered with short hair, and the lateral margins bear three large teeth behind the outer orbital angle. Between the clefts the front is cut into a number of sharp teeth. The chelipeds are covered with rounded tubercles, some of which are disposed in rows. The meri of the walking legs are expanded and spinate along their anterior margins and all the joints are ridged, the intervening grooves being filled with hair. The dactyli carry two rows of spines. Adult males are about 50 mm. in carapace breadth.

Distribution. This is best described as circum-subantarctic as the crab occurs on the southern shores of Australia, Africa, and South America and islands included in this zone.

Remarks. Like *Leptograpsus* this is an inhabitant of exposed rocky coasts. Its wide range is probably explained by the fact that this and other species of the genus, although normally shore dwellers, are sometimes found on drifting timber in the open sea.

FIG. 9.—*Heloecius cordiformis*, ♂

Family OCYPODIDAE

This family is distinguished from the *Grapsidae* by the narrow front and correspondingly long orbits and eyestalks, each of which is usually at least a third of the width of the carapace. In addition the external maxillipeds do not leave a wide gap between them when closed.

Like the Grapsids the Ocypodid crabs are shore dwellers and amphibious in habits. Nearly all live in burrows in sand or mud. Most of them feed in a curious and characteristic manner. When the falling tide lays bare a stretch of mud or sand it leaves on the surface a thin film or scum of organic matter. On this the Ocypodids feed, scraping it up with their spoon-shaped fingers. The sand-dwelling forms seive the sand they put in their mouths, discarding the coarser grains in the form of little pellets, just as do the closely allied Mictyrids.

Only two Ocypodid crabs are known from Tasmania.

Heloecius cordiformis (Milne Edwards). Fig. 9

Haswell, 1882, p. 91.
Ward, 1928, p. 242.

Material. Specimens from Brown's River, near Hobart, and Orford, on the east coast.

Description. The carapace is convex, broad in front and narrow behind, with the regions well marked and the hepatic regions very prominent and inflated so that they almost overhang the small, sharp, forwardly directed outer orbital

angles. The posterior part of each branchial region is separated by a raised line from the rest of the carapace and forms a triangular facet. The front is reduced to a narrow lobe between the bases of the eye-stalks, which are very long. The chelipeds of the adult male are large and greatly elongated, the length of the hand alone being equal to the breadth of the carapace. The immovable finger is bent down at an angle to the palm, which is bordered above and below by a finely milled ridge. The fingers are spoon-shaped at the tips and dentate along their biting edges. The walking legs are smooth, the meri of the first three somewhat hairy at the anterior and posterior margins. Each of the external maxillipeds has a broad, longitudinal groove traversing the ischium and merus.

Colour. The carapace, legs, and proximal joints of the chelipeds are dark greenish blue obscurely mottled with brown, the palms of the chelae dull slate blue, paler distally, and fading to dirty white on the fingers (1).

Distribution. Tasmania, New Zealand, Victoria, and the east coast of Australia; the most northern locality from which the Australian Museum possesses specimens is Brisbane.

Remarks. In Tasmania these crabs inhabit burrows in mud between tide marks near the mouths of rivers; further north they live in mangrove swamps. From their habit of brandishing their chelipeds in the air as if signalling to each other, they are often called " Semaphore Crabs ". Ward (l.c.) gives a good account of their habits.

(1) There is probably some distributional variation in the colour: small specimens collected near Sydney have the chelae bright red which turns to purple in the adult. No Tasmanian examples that I saw were thus coloured.

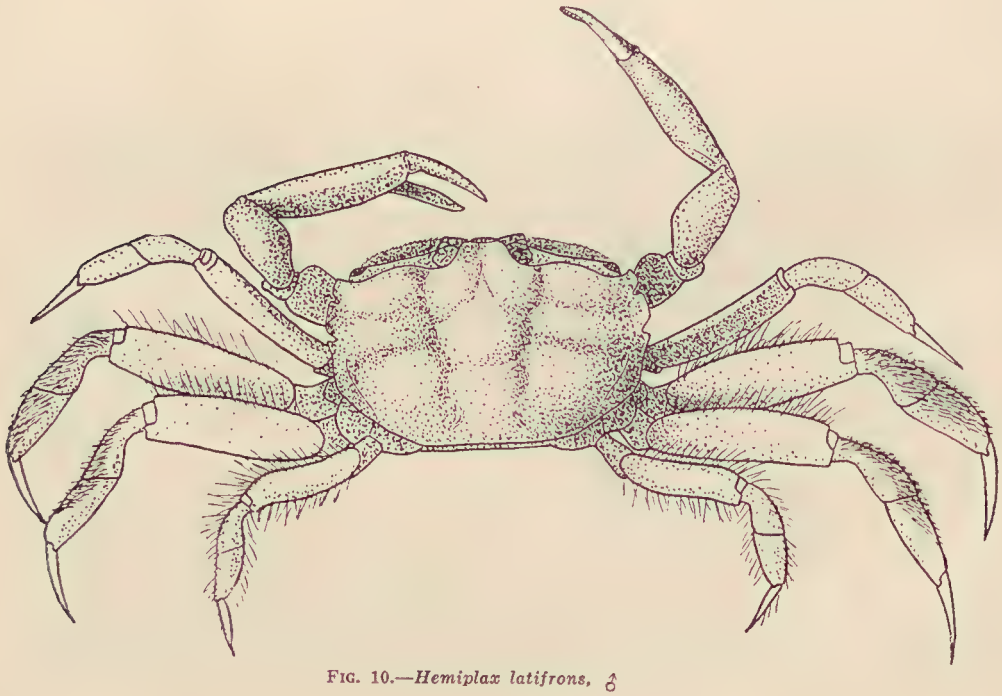

FIG. 10.—*Hemiplax latifrons*, ♂

Hemiplax latifrons (Haswell). Fig. 10

Haswell, 1882, p. 90 *(Macrophthalmus latifrons).*
Etheridge and McCulloch, 1916, p. 13.
Hale, 1927 a, p. 186.

Material. Specimens from the River Carlton, and from Orford on the east coast, compared with the type in the Australian Museum.

Description. The carapace is broad, about half as wide again as it is long, and the inter-regional grooves are well marked. The lateral borders are slightly convex and divided anteriorly by two notches into three teeth (including the outer orbital angle). The second of these is broad and blunt and the third small and angular, and both are turned up so that their edges are considerably above that of the outer orbital angle. The front is between $\frac{1}{4}$ and $\frac{1}{5}$ of the breadth of the carapace, and its upper surface is concave. The upper orbital border is sinuous and finely beaded, and the lower is prominent, being visible in dorsal view, and finely denticulate. The chelipeds of the adult are long and fairly robust, those of females and young males small and slender. The chelae are finely granular over the whole of their surface, and the palm and immovable finger are bordered below by a ridge which tends to become obsolete in large males, but is very prominent in females. The immovable finger curves down from the palm, and both fingers are denticulate on the biting edges except at the base of the dactylus. The walking legs are fairly long and very hairy, the hair being especially thick on the carpi and propodi of the second and third legs. The largest male is 27 mm. in carapace breadth.

Colour. Dark greenish or greyish brown; the chelae paler. I have seen no specimens approaching "creamy yellow" as described by Hale (l.c.), p. 187.

Distribution. Tasmania and south-eastern Australia.

Remarks. The characters of this species are misrepresented in Tesch's key to the genus *Macrophthalmus* (1915, p. 154, 155). It is placed in category 17 ("greatest breadth of carapace between the outer orbital angles"), whereas in reality the greatest breadth is at the level of the hindmost lateral teeth, and the species should be in category 20.

These crabs live in burrows in soft mud. They are found at low tide in the same localities as *Heloecius*, but always nearer the water's edge. They also extend further up the rivers than *Heloecius*, and are therefore probably more tolerant of fresh water.

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NATIONAL MUSEUM OF V...

Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

New Leaf-Hoppers from Tasmania and Queensland

By

J. W. Evans

(Read 13th October, 1941)

Plate III

EUPTERYGIDAE

Empoasca maculata sp. nov.

(Plate 3, fig. 11)

Length 3 mm. General coloration bright yellow. *Head*, ventral surface white, but for the fronto-clypeus antero-laterally, which is green; eyes, black. Crown yellow, with or without white markings; ocelli marginal, large. *Pronotum* yellow with irregular white markings, usually four in number, lying against the anterior border. *Scutellum* yellow with white markings. *Tegmen* yellow, hyaline with a distinct brown spot in the distal portion of the cell that lies between the claval suture and Cu_1. *Male Genitalia* as in Pl. 3, fig. 11. *Type* ♂ from Jandowae, Queensland, on cotton (D. Atherton, 4/4/41), in the Queensland Museum collection (Ho. 15228).

Note.—*E. maculata* resembles *E. terrae-reginae* Paoli in the shape and colour-pattern of the head and pronotum. If differs in colour, being yellow and not green, and may be readily identified by the presence of the brown spot on the tegmen.

Eutambourina gen. nov.

The ventral surface of the head, which is triangular in shape, is irregularly pitted. The pits, which resemble those that occur in the Fulgoroidea, are shallow and have thickened margins. Frontal and coronal, but not epicranial, sutures are developed. The crown, which is wider in the centre than against the eyes, is rounded anteriorly and depressed posteriorly. The pronotum is pitted and wider posteriorly than anteriorly, and the sides of the scutellum are raised. The venation of the tegmen is similar to that of *Erythroneura*, excepting that an anal vein is developed. The pleura and the dorsal surface of the abdominal segments are pitted, and the hind tibiae have three rows of long spines.

Eutambourina punctata sp. nov. (Genotype)

(Plate 3, figs. 12-14)

Length 3·8 mm. *Head*, ante-clypeus brown, smooth; lora and maxillary plates brown with yellow pits; fronto-clypeus and vertex yellow, but for a brown spot at the apex of each frontal suture, and a pair of broad longitudinal brown stripes

that extend posteriorly almost as far as the hind margin of the crown. *Pronotum* and *Scutellum* pale lemon yellow. *Tegmen* hyaline, pale yellow partially suffused with brown, and with a whitish oval area lying against the costal border. *Thorax*, pleural sclerites brown with yellow pits. *Abdomen* pale yellow. *Male Genitalia* as in Pl. 3, fig. 14. *Type* ♂ from Tambourine Mountains, Queensland (R. E. Turner 5/35), in the British Museum collection.

IDIOCERIDAE

Idiocerus tambourinus sp. nov.

(Plate 3, figs. 1, 2)

Length 4·5 mm. *Head*, ventral surface, ante-clypeus, lora and maxillary plates yellow; fronto-clypeus yellow, but for a rose-pink median area close to the hind border; vertex and eyes rose-pink; ocelli yellow, and two yellow muscle impressions between the ocelli and the hind margin of the head. Crown of even width throughout. *Pronotum* with a median pink longitudinal stripe, bordered on each side by yellowish-grey, pink, black, red and yellow zones; these are not distinct stripes but merge into each other. *Scutellum* deep pink, muscle impressions black. *Tegmen* hyaline, greenish-yellow; apex smoky-brown with a broad black band, merging into pink, against the hind border. *Thorax* and *Abdomen*, ventral surface pale yellowish-green. *Male Genitalia* as in Pl. 3, fig. 2. *Type* ♂ from Tambourine Mountains, Queensland (R. E. Turner 6/35), in the British Museum collection.

Note.—This is a somewhat variable species, but the general effect of the colour-pattern is as shown in Pl. 3, fig. 1.

Idiocerus lacustris sp. nov.

(Plate 3, fig. 3)

Length 5 mm. General coloration yellowish-green. *Head* convex; crown wider in the centre than against the eyes; eyes brown. *Pronotum* shorter than the scutellum. *Tegmen* hyaline-green, apically brown; venation indistinct. *Thorax*, ventral surface pale green. Hind tibia with four spurs set on prominent bases. *Abdomen*, ventral surface pale green. *Male Genitalia* as in Pl. 3, fig. 3. *Type* ♂ from near Lake St. Clair, Tasmania (J. W. E. 2/41), in the Australian Museum collection.

CICADELLIDAE

Cicadella turneri sp. nov.

(Plate 3, fig. 4)

Length 8 mm. *Head*, ventral surface bright yellow, the ante-clypeus tinged with brown; fronto-clypeus bordered with black posteriorly; eyes black, crown yellow with black markings. *Tegmen* greenish-black, apically dark smoky-brown. A narrow yellow hyaline band extends the full length of the costal margin, but is separated from the actual border by a narrow black band. *Thorax* and *Abdomen*, ventral surface yellow. *Type* ♀ from Tambourine Mountains, Queensland (R. E. Turner 4/35), in the British Museum collection.

MACROPSIDAE

Macropsis wellingtonensis sp. nov.

(Plate 3, fig. 6)

Length 4 mm. *Head*, ventral surface whitish-yellow with sparse brown punctures, muscle impressions ochreous, eyes dark-brown. Crown wider in the centre than against the eyes. *Pronotum* declivous, sordid whitish-yellow with brown punctures. *Scutellum* yellowish-brown laterally and with a median longitudinal white stripe that widens apically. *Tegmen* colourless-hyaline with four ill-defined blackish-brown transverse areas; veins black and brown with white bars. *Thorax*, ventral surface yellow with dark-brown markings. Hind tibia yellowish-white, the bases of the spines dark-brown. *Abdomen*, ventral surface yellow with dark-brown markings. *Type* ♂ from Mt. Wellington, Tasmania (4000 ft.) (J. W. E. 12/40), in the Australian Museum collection.

Macropsis fergusoni sp. nov.

(Plate 3, fig. 6)

Length 5 mm. *Head*, ventral surface diamond-shaped, pale brownish-yellow with dark-brown punctures; eyes red. Crown visible from above only as a narrow margin against the eyes on each side. *Pronotum* steeply declivous anteriorly, brown punctures. *Scutellum* yellowish-brown laterally and with a median remainder whitish with sparse dark-brown punctures. *Tegmen* whitish-hyaline evenly mottled with black; veins yellow. *Thorax*, ventral surface black, the pleural sclerites edged with yellow. *Abdomen*, ventral surface yellow. *Type* ♀ from Ferguson's Camp, Lake St. Clair, Tasmania (J. W. E. 2/41), in the Australian Museum collection.

ULOPIDAE

Taslopa gen. nov.

The head is produced and acute apically, and resembles that of *Ulopa* Fall, rather than the head of *Australopa* Ev., in that the ante-clypeus is pear-shaped and the fronto-clypeus does not overhang the ante-clypeus. The head and the ventral surface of the thorax are ornamented with white shining dots that resemble grains of sugar.

Taslopa montana sp. nov. (Genotype)

(Plate 3, figs. 9, 10)

Length 4 mm. *Head*, ventral surface marked with a pattern of light and dark-brown, antennal depressions black. Crown raised and rugose medially; ocelli slightly closer to the fore than to the hind border. *Pronotum* steeply declivous, brown. *Scutellum* dark-brown with yellow markings. *Tegmen*, clavus opaque and coriaceous, the remainder colourless-hyaline; veins brown. *Thorax*, ventral surface, prothorax brown, meso- and metathorax black. *Abdomen*, ventral surface brown. *Type* ♀ from Mt. Wellington, Tasmania (4000 ft) (J. W. E. 12/40), in the Australian Museum collection.

Taslopa brachyptera sp. nov.

(Plate 3, figs. 7, 8)

Length 4 mm. *Head*, ventral surface marked with a pattern of light and very dark-brown; close to the hind margin is an oval swollen prominence. Crown flat with a median longitudinal ridge; ocelli small and inconspicuous. *Pronotum* on a plane with the crown, brown. *Scutellum* concolorous with the pronotum and with two yellowish markings. *Tegmen* brachypterous, coriaceous, brown but for a whitish streak that widens posteriorly and terminates anteriorly against the hind margin of the pronotum, and a black oval marking. *Thorax*, ventral surface marked with a pattern of brown and black. *Abdomen*, dorsal surface brown streaked with yellow and with ten brown spots on each segment; ventral surface brown. *Type* ♀ from Mt. Wellington, Tasmania (4000 ft.) (J. W. E. 12/40), in the Australian Museum collection.

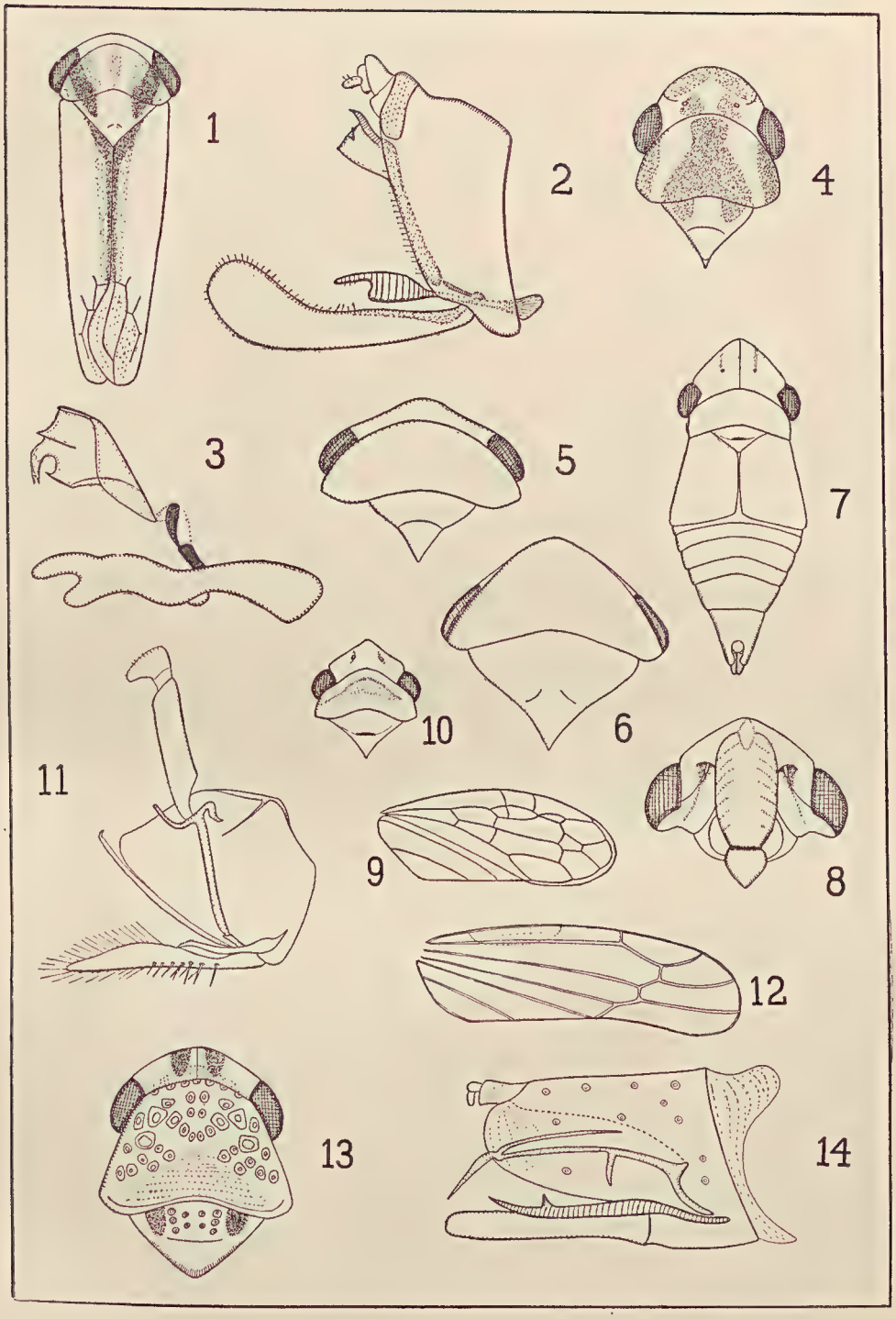
Notes

It has been discovered by field observation that a leaf-hopper described as *Austroagalloides rosea* Ev. is the female of one named *A. nigra* Ev. (1936). Accordingly *A. nigra* becomes a synonym of *A. rosea*.

In a collection of Australian leaf-hoppers recently received from the British Museum were three specimens of the Eurymelid, *Bakeriola procurrens* (Jac.), bearing the locality label " Townsville, Queensland, F. P. Dodd, 5/03 ". This is a most surprising distribution record, as formerly this species was thought to be confined to Western Australia.

Plate III

Fig. 1.—*Idiocerus tambourinus.*
Fig. 2.—*I. tambourinus*, male genitalia.
Fig. 3.—*Idiocerus lacustris*, aedeagus and paramere.
Fig. 4.—*Cicadella turneri*, head and thorax, dorsal aspect.
Fig. 5.—*Macropsis wellingtonensis*, head and thorax, dorsal aspect.
Fig. 6.—*Macropsis fergusoni*, head and thorax, dorsal aspect.
Fig. 7.—*Taslopa brachyptera.*
Fig. 8.—*T. brachyptera*, tegmen.
Fig. 9.—*Taslopa montana*, head in ventral aspect.
Fig. 10.—*T. montana*, head and thorax, dorsal aspect.
Fig. 11.—*Empoasca maculata*, male genitalia.
Fig. 12.—*Eutambourina punctata*, tegmen.
Fig. 13.—*E. punctata*, head and thorax, dorsal aspect.
Fig. 14.—*E. punctata*, male genitalia.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NATIONAL MUSEUM OF VICTORIA

Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

A Mecopterous Larva from Tasmania and Notes on the Morphology of the Insect Head

By

J. W. Evans

(Read 13th October, 1941)

Plate IV

In some spirit material which was sorted during the winter of 1941, two larval Mecoptera were discovered. They had been collected in moss on Mt. Wellington during the previous January, at an elevation of between two and three thousand feet.

Four species of Mecoptera are known to occur on Mt. Wellington. These are *Harpobittacus australis* Klug. (Bittacidae); *Apteropanorpa tasmanica* Carp. (Panorpidae); *Nannochorista dipteroides* Tillyard and *N. maculipennis* Tillyard (Nannochoristidae). The larva of *Harpobittacus* has been described (Currie, 1932), and in no way resembles those found. It is probable that these are the larvae of a *Nannochorista* and not of *A. tasmanica*, because the moss was from an environment frequented by *N. dipteroides*. *A. tasmanica* and *N. maculipennis* have so far only been taken in open country, at an elevation of about four thousand feet.

Tillyard (1917) believed *Nannochorista* larvae to be aquatic, because the adult insects are almost always taken close to water. However, as they can be found in equal abundance both close to stagnant alpine pools and to fast-flowing streams, damp moss might even more be expected to provide their natural environment. The suggestion that the larvae are those of *Nannochorista* is supported by their structure. Adult *Nannochorista* spp. retain more archaic characters than any other representatives of the Eumecoptera; hence their larvae might well be expected to have primitive features. The larvae described in this paper are less specialized than any described Mecopterous larvae, and have, as well, certain unusual primitive features associated with the structure of the head.

Applegarth (1939) has stated that very little is known concerning larval Mecoptera, yet they are of the very greatest interest, because it is accepted that the Mecoptera are directly ancestral to all Holometabolous orders of insects, with the exception of the Coleoptera. Further, as the nymphs of all the Hemimetabola hatch from the egg in a post-oligopod phase, which is a later ontogenetic stage than that retained by the larvae of Holometabolous insects, in a polypod Mecopteron larva may be expected to occur more primitive structural characteristics than in any other pterygote insect.

Description

The two larvae are five and six millimetres long respectively. They are brown in colour and probably in their second instar.

The Head

The head is illustrated in Plate IV, figures 1-3. Figure 1 represents the head in facial aspect. Posteriorly a median oval area, the occiput, is separated from the rest of the head by inwardly-curved lateral sutures. Anterior to the occipital sutures are a pair of lateral folds, the postfrontal folds. The coronal suture is the median suture that extends from the hind margin of the occiput to the apex of the frons. The frons is delimited posteriorly by a V-shaped suture, the epicranial suture; laterally by a pair of more or less parallel frontal sutures and anteriorly by the epistomal suture. The epistomal suture is more pronounced than the other sutures and consists of a thickened sunken fold. The median portion of the frons is separated from the rest by a V-shaped ridge and bears a raised tubercle antero-medially.

Lying on each side of the frons, between it and the eyes, are the genae. These are bounded posteriorly by the postgenal sutures, which extend from the eyes on each side as far as the junction of the epicranial and the frontal sutures. The sub-ocular sutures extend from the margin of the eyes on each side as far as the frontal sutures. The clypeus is rectangular, sclerotized anteriorly, and the labrum is wide. The eyes comprise sixteen ommatidia, which lie close together in a compact group. The antennae have three segments. The first is reduced to a narrow band, the second is bulbous and bears several large sensory pits, arranged more or less in two rows, and the apical segment is spine-like. The anterior tentorial pits lie against the frontal sutures between the sub-ocular and the epistomal sutures.

Figure 2 represents the head in ventral aspect. The post-occiput, which consists of a pair of narrow sclerites separated from the rest of the head by the post-occipital suture, borders the foramen magnum on each side, and the cervical sclerites articulate with the occipital condyles, which lie in the centres of the two sides of the post-occiput. The labium consists only of a longitudinally divided sub-mentum and a pair of palps, and the posterior tentorial pits are invaginated between the sub-mentum and the post-occiput.

The Thorax

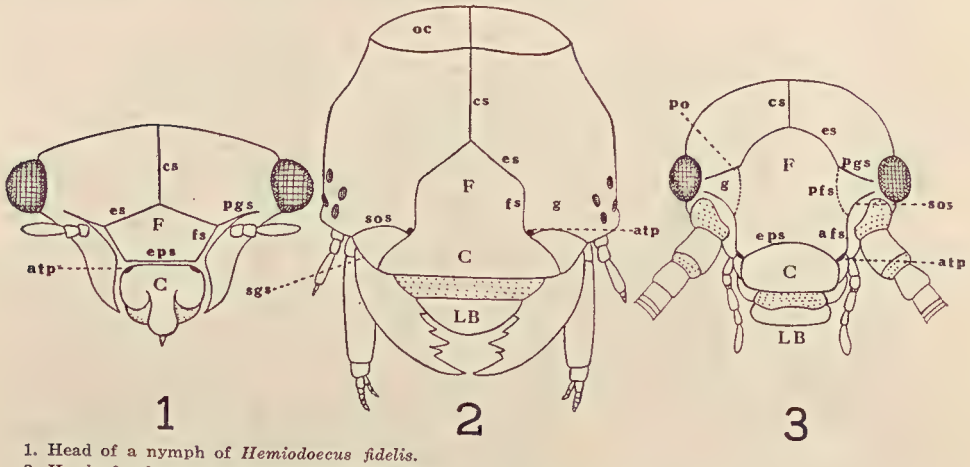
The first and second thoracic segments are illustrated in Plate IV, figures 3 and 5. The metathorax resembles the mesothorax in all essential features. Between the head and the thorax is a distinct neck region, which is supported by a bow-shaped cervical sclerite. Both the meso- and meta-thorax have several raised bosses armed with delicate spines; the position of these is indicated in the figures. The legs have each three segments and their apices are hook-shaped.

The Abdomen

An abdominal segment typical of segments 1-7 is illustrated in Plate IV, figures 4 and 6. The terminal segments are illustrated in figure 7. There are ten abdominal segments, the first eight of which bear a pair of appendages and the first nine a pair of spiracles. The appendages, which are simple processes, are slightly curved in a forward direction. In addition to spines (fig. 8c), each of the abdominal segments 1-9 bears a pair of small dorsal processes (fig. 8a), whilst segment 10 has a somewhat larger median dorsal process (fig. 8b). There is a sensory pit close to the base of each dorsal paired process.

Discussion

In certain groups of insects, such as the Dermaptera, a triangular area may occur in the frontal region of the head which is bordered by faint lines or ridges, but not true sutures, and in addition a pair of widely divergent sutures extend outwards from the anterior apex of the coronal suture. Snodgrass (1935) is of the opinion that these widely divergent sutures are not homologous with true frontal sutures, and following Crampton (1932) terms them postfrontal sutures. This is because not only do these sutures extend as far as the eyes on each side but they may also lie posterior to the paired ocelli.



1. Head of a nymph of *Hemiodoecus fidelis*.
2. Head of a larva of *Archichauliodes dubittatus*.
3. Head of a nymph of *Tasmanoperla* sp.

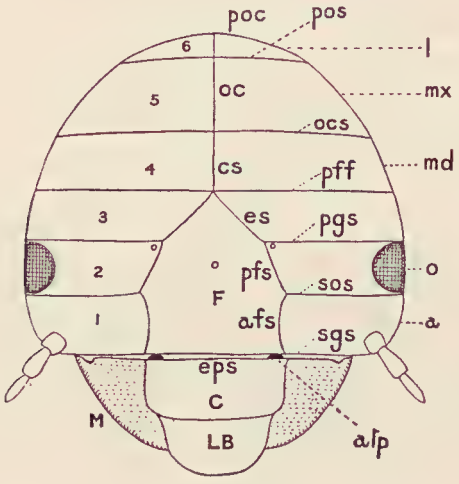
afs., anterior frontal suture; atp., anterior tentorial pit; C., clypeus; cs., coronal suture; es., epicranial suture; eps., epistomal suture; F., frons; fs., frontal suture; g., gena; LB., labrum; oc., occiput; pfs., posterior frontal suture; pgs., postgenal suture; po., position of ocellus; sgs., subgenal suture; sos., subocular suture.

In certain insects the frons, instead of being triangular in shape, as is usual, is either five- or seven-sided. Examples of such a frons occur in the nymph of *Hemiodoecus fidelis* Evans (Homoptera, Peloridiidae), the larva of *Archichauliodes dubittatus* Walk. (Neuroptera Corydalidae), the nymph of *Tasmanoperla* sp. (Perlaria, Austroperlidae), and the larva of *Perga* spp. (Hymenoptera, Tenthredinidae). The heads of the three first-named are illustrated in Text-figures 1-3.

The frons of the larva of *Nannochorista* (?) has seven sides, and it is suggested that such a condition is ancestral to a triangular frons.

Following the use of terms already employed in describing the heads of Homoptera (Evans, 1938), the posterior sutures of the frons are referred to as the epicranial sutures and the lateral sutures as the frontal sutures. Each frontal suture consists of an anterior and a posterior frontal suture. The sutures that arise from the anterior apices of the epicranial sutures on each side of the head, and which extend as far as the eyes, have been named, earlier in this paper, the postgenal sutures. It is believed that the postfrontal sutures of Snodgrass and Crampton are the combined epicranial and postgenal sutures. Further, the lateral sutures of a triangular frons are made up of combined epicranial and frontal sutures. In *H. fidelis* epicranial, postgenal, frontal, and epistomal sutures are

present. In *A. dubittatus* epicranial and frontal sutures are developed, but not postgenal and epistomal sutures. In *Tasmanoperla* epicranial, postgenal, anterior frontal, posterior frontal, and epistomal sutures are all present, as they are likewise in *Nannochorista* (?). Paired ocelli, when present, lie in the angles between the postgenal and frontal sutures; their position is indicated in Text-Figure 3 (po.).



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4. Hypothetical insect head to illustrate the basic segmentation.

a., antennal segment; l., labial segment; m., mandible; md., mandibular segment; mx., maxillary segment; o., ocular segment; ocs., occipital suture; pff., postfrontal fold; pos., post-occipital suture. Other lettering as in previous figures.

Thus the head is seen to have several distinct transverse sutures, of which the three posterior continue across the head and the three anterior are interrupted by the frons. Text-figure 4 is a diagrammatic representation of an insect head based on the head of the larva of *Nannochorista* (?) and on the heads illustrated in Text-figures 1-3. The subocular suture is not homologous with the subocular suture of Snodgrass (fig. 58a), which is the anterior frontal suture, as is also his subantennal suture (fig. 59a). It is possible that the sclerite numbered 1 in Text-figure 4 may be homologous with the sclerite lying anterior to the eyes in *Chauliognathus pennsylvanicus* de Geer (Coleoptera, Cantharidae) figured by Campau (1940), with the anterior lateral sclerites of *A. dubittatus* and with the antennal sclerite of *Tasmanoperla*. Whether this sclerite is also homologous with the pleurostoma of certain Orthoptera is uncertain. In *Corydalus*, Comstock (1920), who termed these sclerites the ante-coxal pieces of the mandibles, believed them to be of clypeal origin. Somite 3, to which no appendage has been assigned, may be identified either with the first postoral somite, as illustrated in Snodgrass (fig. 54a), or with the mandibular somite. If the latter, then somite 4 will be the superlingual segment.

The significance of the median triangular area of the frons is uncertain (Plate IV, fig. 1); it may be associated with the tentorium, as the sides of the triangle lie immediately above the anterior arms of the tentorium. Although

homologous with a similar area to be found in some Dermaptera, it is not homologous with that of Lepidopterous larvae, where it consists of the clypeus. The raised tubercle figured may precede the median ocellus.

The head of the first instar larva of *Panorpa klugi* Maclachlan, figured by Miyake (1912), resembles that of the larva of *Nannochorista* (?) in general features. The frons of the latter is narrower and more elongate, postgenal and occipital sutures are not developed, and the eyes have twenty-eight ommatidia. In addition the labial palps are shorter in relation to the maxillae, and the antennae have more numerous sensory pits.

Crampton has illustrated a head of a *Panorpa* sp. which resembles the head of the Tasmanian insect in the retention of a distinct occipital region, and in the possession of a five-sided frons. It differs in having a pair of transverse sutures that extend widely from the junction of the coronal and epicranial sutures as far as the antennae on each side, and in lacking postgenal sutures. Such an unusual development is difficult to comprehend, unless it is supposed that Crampton's paired transverse and anteriorly directed sutures are actually combined epicranial and postgenal sutures, and his frons identical with the area in Plate IV, fig. 1 which is bordered by dotted lines. This median frontal area is also differentiated in *Apterobittacus apterus* Maclachlan, figured by Applegarth.

With regard to the ventral surface of the head, the labium in *Nannochorista* (?) is better developed than in *A. apterus* and *Harpobittacus tillyardi* E. P., whilst in *Apterobittacus* no trace remains of the distinct divided sub-mentum of *Nannochorista.*

The single thoracic spiracle is in an identical position in *Nannochorista* (?) and *P. klugi,* but in *Apterobittacus* it lies directly below the pronotum, and the arrangement of the thoracic setae of *Nannochorista* (?) is similar to, though not identical with, that of *P. klugi.*

The abdomen of the larvae of *Nannochorista* (?) differs from that of other known Mecopterous larvae in lacking dorsal annulated setae, such as are well developed in every segment of first-instar specimens of *P. klugi,* and retained though reduced, excepting on the eighth and ninth segments, in later instars. The simple nature of the setae of *Nannochorista* (?) can best be explained on the grounds that they are primitive rather than reduced structures.

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Plate IV

Fig. 1.—Head of larva of *Nannochorista* sp. (?) in facial aspect. atp., anterior tentorial pit; cs., coronal suture; eps., epistomal suture; es., epicranial suture; fs., frontal suture; g., gena; oc., occiput; ocs., occipital suture; pff., postfrontal fold; pgs., postgenal suture; sos., subocular suture.

Fig. 2.—Head of larva of *Nannochorista* sp. (?) in ventral aspect. csl., cervical sclerite; occ., occipital condyle; poc., post-occiput; pos., post-occipital suture; ptp., posterior tentorial pit; smt., sub-mentum.

Fig. 3.—Head and two anterior thoracic segments of the larva of *Nannochorista* sp. (?) in lateral aspect. sp., spiracle; csl., cervical sclerite.

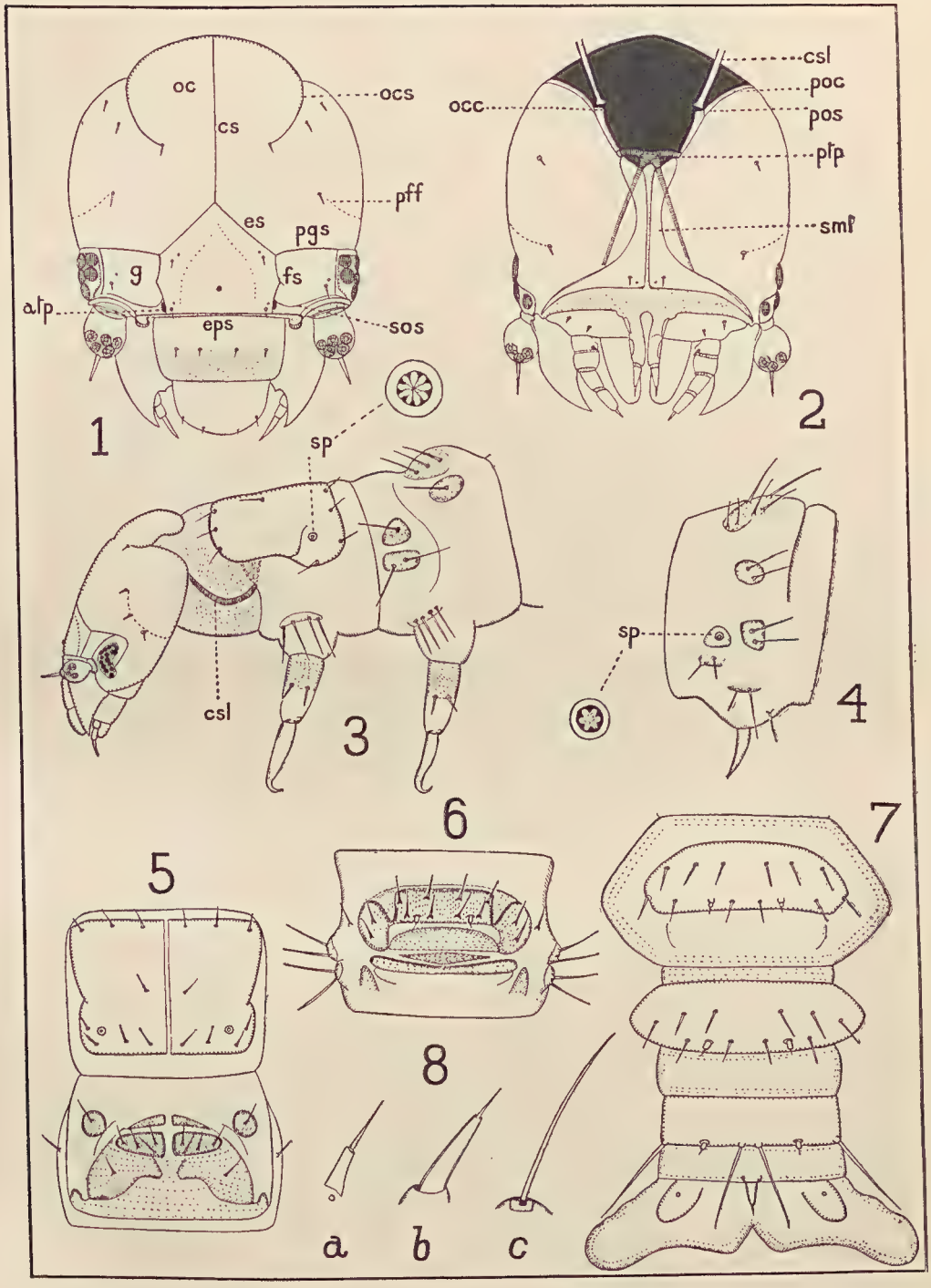
Fig. 4.—Second abdominal segment of the larva of *Nannochorista* sp. (?) in lateral aspect.

Fig. 5.—Two anterior thoracic segments of the larva of *Nannochorista* sp. (?) in dorsal aspect.

Fig. 6.—Second abdominal segment of the larva of *Nannochorista* sp. (?) in dorsal aspect.

Fig. 7.—Apical abdominal segments of the larva of *Nannochorista* sp. (?) in dorsal aspect.

Fig. 8.—(a) dorsal abdominal process; (b) median terminal dorsal abdominal process; (c) thoracic and abdominal seta.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Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

37

The Phylogeny of the Homoptera

By

J. W. Evans

(Read 10th November, 1941)

The question of the phylogeny of the Homoptera does not remain unsettled for want of discussion, as several authors have expressed most definite, though often contradictory, views on the subject. A few years ago a Bulletin entitled 'The Phylogeny of the Hemiptera based on the Study of the Head Capsule' was published in the United States (Spooner, 1938). This work is no mere short paper, but a considerable contribution of over one hundred pages, containing close on four hundred figures. For this reason, quite apart from its obvious worth as a contribution to the comparative morphology of insects, it merits close attention. It consists of two parts; the first part deals with the Homoptera and the second with the Heteroptera, and at the end of each part the conclusions reached by the author with respect to phylogeny are expressed as trees. As far as the Heteroptera are concerned, no comment is offered, but the present paper has been written to dispute certain conclusions reached by Spooner regarding the inter-relationships of the Homoptera, and to present alternative proposals.

In the phylogenetic tree for the Homoptera three main lines of descent are shown radiating from the Protohomopterous stem. Two of these give rise to the Fulgoridae and Peloridiidae respectively and the third to the Cercopidae, all the several other groups of Homoptera, apart from those mentioned above, then being derived direct from the Cercopidae. The separate derivation of the Fulgoridae and Peloridiidae from the Protohomopterous stem is not questioned, in fact an identical suggestion has been made previously (Evans, 1938). The points disputed are the derivation of the Sternorrhyncha from the Cercopidae and the dual origin claimed for the Jassoidea.

Crawford (1914) in his monumental work on the Psyllidae suggested that many characters borne by the group point to a close relationship with the higher Homoptera, especially the Cicadidae, Membracidae, and related families. At the same time he acknowledged that he was not prepared to make a definite pronouncement on relationships. Muir (1930) was of the opinion that the Psyllidae represent a specialization, considerably by reduction, of the Cicadoidea, and Myers (1929) believed that the relative simplicity of the Sternorrhyncha was a secondary specialization. Tillyard (1926), as a result of a study of the wing venation of Lower Permian Homoptera, suggested that the Sternorrhyncha were less primitive than the Auchenorrhyncha. Nevertheless, although there would seem to be fairly general agreement that the Sternorrhyncha, and the Psyllidae in particular, are derived from the Auchenorrhyncha, contrary views have been expressed. Thus Kirkaldy (1906) mentions that Ashmead, in a discussion of Osborn's paper on the phylogeny of the Homoptera (Osborn, 1895), put forward the suggestion that the Auchenorrhyncha were derived from the Sternorrhyncha.

Ideas on relationships based on the study of a single character are notoriously unreliable, but it is believed that, so far as the Homoptera are concerned, the structure of the head-capsule, correctly interpreted, offers a reasonable basis for phylogenetic conclusions.

If a comparison is made between the heads of an aphid, a psyllid, and a nymph of a peloridiid, it will at once be seen that they possess a striking characteristic in common. This is the separation of the head into two parts by the epistomal and subgenal sutures. There are other resemblances as well which can best be appreciated by reference to published figures. If first the head of a nymph of the peloridiid *Hemiodoecus fidelis* (illustrated in Evans, 1938, 1942; Snodgrass, 1938) is compared with the head of the psyllid *Paurocephala magnifrons* (Crawford, Pl. 3, fig. 16), the following points will be noted. Both have a distinct five-sided frons, from the posterior corners of which postgenal sutures arise, and both have a small distinct clypeus which is not separated into two parts by a transverse suture. Spooner gives a figure of the head of the psyllid *Pachypsylla celtidis-mamma* (Pl. 2, fig. 34) in which the clypeus is indicated as possessing two parts. This is because the genal cones have been labelled 'post-clypeus' and the actual complete clypeus 'ante-clypeus'.

The retention of a postgenal suture in the Psyllidae is of considerable interest. It extends from the lateral apices of the frons on each side in the direction of the eyes, and then from close to the eyes continues posteriorly, more or less at right angles to its former direction, as far as the hind margin of the head. On the crown it may either lie against the internal margins of the eyes or be slightly separated from them. The paired ocelli lie close to the apices of these sutures. Apart from in the Psyllidae and in the nymphs of the Peloridiidae, postgenal sutures do not occur in any other Homopterous types, although they are present in a few other groups of insects, such as the Dermaptera and Perlaria. In these, where lateral frontal sutures are absent, the true identity of postgenal sutures as such, has not been recognized and they have been referred to as 'postfrontal sutures' (Snodgrass, 1935). Such postfrontal sutures actually comprise combined epicranial and postgenal sutures (Evans, 1942).

If next the head of an aphis, such as *Lachnus* sp. (Spooner, Pl. 2, fig. 33), is compared with the head of *Hemiodoecus*, two noteworthy resemblances will be apparent. Both have complete small maxillary plates which are not attached in any way to the genae, and both have a clypeus without a transverse division, but with lateral lobes. These lobes are homologous with the lora of the Auchenorrhyncha.

The following characters of the Homopterous head are believed to be primitive: the complete separation of the clypeus from the frons; the complete separation of the maxillary plates from the genae; the possession of a clypeus lacking a median transverse division; the possession of a clypeus with lateral lobes which are separated from the median part of the clypeus by sutures that do not extend as far as the epistomal suture. The following are believed to be secondary developments: the partial or complete fusion of the frons with the clypeus and the enlargement of the clypeus at the expense of the frons; the fusion of the maxillary plates with the genae; the separation of the clypeus into two parts by a transverse division; the backward extension of the longitudinal clypeal sutures, their junction with the lateral frontal sutures, and the partial or complete obliteration of the epistomal suture.

Snodgrass (1938) has suggested that one of the characters claimed above as primitive is actually a secondary development. According to him, the lateral lobes of the clypeus are of hypopharyngeal origin and their connexion with the

post-clypeus a secondary union. In his opinion the obliteration of the clypeoloral sutures which occurs in the Peloridiidae, Aphididae, and certain Fulgoroidea is a progressive development from the condition which occurs in the majority of the Auchenorrhyncha, where separate loral plates are present. Whilst unable to offer an alternative explanation to account for the union of the lora with the hypopharynx, the hypothesis proposed by Snodgrass is not accepted. This is because of the supporting array of characters in the Peloridiidae, which are undoubtedly of a primitive nature.

In the cercopid head, not only are the maxillary plates fused with the genae, but no trace remains of the subgenal suture; the clypeus is divided into two parts and enormously enlarged posteriorly, and the epistomal suture, in those species where it may still be recognized, is so arched that the anterior tentorial pits lie close to the antennae. No trace of postgenal sutures remains, and, in the adult head, even the coronal suture is not distinct.

Thus it is clear that, on the basis of cephalic structure, whilst it might be justifiable to derive the Aphididae and the Psyllidae from the Protohomopterous stem close to the origin of the Peloridiidae and Fulgoroidea, no adequate reasons can be presented to explain a cercopid origin for the Sternorrhyncha. Carpenter (1932) has proposed the name Palaeorrhyncha for a division of the Homoptera that occurred in Permian times and which, with respect to wing venation, combined the main features of recent groups. It may well be that the Auchenorrhyncha and the Sternorrhyncha have both arisen from the Palaeorrhyncha. This suggestion obviates the necessity of attempting to derive either of the two principal present-day Homopterous divisions from the other.

In regard to the origin of the Jassoidea, Spooner has suggested that the group represented by *Oncometopia* Stål (Cicadellidae) may have been derived from the Cercopinae and all the several other jassoid families from the Aphrophorinae. Whilst not disputing that the suggestion is reasonable if head structure alone is considered, other characters lend it no support. For instance, in the hind-wings of insects in all jassoid families, with the exception of the Aethalionidae, the media has two branches ($M_1 + _2$ and $M_3 + _4$) although occasionally $M_3 + _4$ may be fused apically with $M_1 + _2$, also the first cubital vein is undivided. In both the Cercopinae and the Aphrophorinae the media terminates as a single vein, whilst Cu_1 has two branches, Cu_{1_a} and Cu_{1_b}. This common characteristic which the Cicadellidae share with other jassoid families is only one of several that could be chosen to stress the fact that, although the Jassoidea may well have arisen from the Cercopidae, they are a monophyletic group. Our present knowledge is insufficient to make definite pronouncements possible concerning other derivations presented in Spooner's phylogenetic tree. Nevertheless, though the Membracidae may have arisen direct from the Cercopidae as suggested in the tree, there is much to be said in favour of deriving them instead from the Jassoidea.

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Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

A New Ichthyobdellid Leech and its Egg-capsules

By

V. V. Hickman

(Read 10th November, 1941)

Plates V, VI

The leech here described was found together with its egg-capsules on a small shell washed-up on the beach at Sandy Bay, Hobart, 28th October, 1940.

There are very few records of marine leeches having been found in association with their egg-capsules, and it seems desirable, therefore, that some account of the present specimens should be published. The leech is a new species belonging to the genus *Pontobdella*. The name *Pontobdella verrucosa* is suggested.

Suborder	Rhynchobdellae
Family	Ichthyobdellidae
Genus	Pontobdella, Leach, 1815

Pontobdella vĕrrucosa n. sp.

Description. Approximate total length, in alcohol, 37 mm.; greatest width 3·5 mm. The body is fusiform, circular in section, and narrowed towards the front (Plate VI, fig. 6). The living animal is light-brown in colour with a dark-brown triangular patch on the dorsal side of the anterior sucker. The larger tubercles are tipped with white, and annuli 23 and 29 are almost ringed with white or pale cream. In alcohol, however, these markings disappear and the leech assumes a uniform mustard-yellow hue without any special marks except the triangular brown patch on the sucker.

The anterior sucker is 2·26 mm. in diameter, cup-shaped, attached excentrically, and provided with four pairs of distinct submarginal papillae. The oral surface of the sucker is corrugated to form 12 radial furrows. No eyes are present.

The posterior sucker is cup-shaped, 3·54 mm. in diameter, attached centrally, much wider than the anterior sucker, but only slightly wider than the greatest width of the body.

There are 57 annuli behind the anterior sucker. A complete somite consists of three annuli. The anterior and posterior annuli of the somite are about equal in width and smaller than the middle ring, which is broad and lodges a ganglion of the ventral nerve chain (Plate V, figs. 1 and 2).

The anterior sucker is composed of somites I-V. Somites VI-IX and XIII-XXIV are complete with three annuli; X-XII are biannulate. The clitellum comprises the five narrow rings lying between the broad annuli of somites X and XIII (Plate V, fig. 1). The annulation and metamerism in the anal region are obscure. Somites XXV-XXVII appear to be uniannulate. Annulus 55 is divided below but not above. There is, however, on the dorsal side a small additional tubercle which is unpaired and which may indicate that the annulus is double. Annulus 56 is divided by a transverse groove on the dorsal side, but there is no corresponding division on the ventral surface. Annulus 57 is complete but without tubercles.

The normal arrangement of tubercles on a typical somite is as follows:—

The broad middle annulus is provided with four large tubercles above and four smaller ones below. The anterior and posterior annuli of the somite have six dorsal and six ventral tubercles. Of the six dorsal tubercles the middle pair are the smallest (Plate V, fig. 2). Sometimes there is a small median ventral tubercle on an annulus, and other small tubercles may be interposed between those normally present.

The mouth is a small central aperture in the front sucker.

The male genital pore lies between annuli 16 and 17; the female aperture is between annuli 18 and 19.

The anus lies in the dorsal transverse groove on annulus 56. The division of the annulus by this dorsal groove makes the anus appear to be separated from the posterior sucker by two annuli (Plate V, fig. 3).

The Egg-capsules

As mentioned above the egg-capsules were found attached to a shell stranded on the beach at Sandy Bay. The adult leech was coiled up over the capsules and was still alive (Plate V, fig. 5). The specimens were placed in sea-water and kept in the laboratory from 28th October to 26th November, 1940. By changing the sea-water frequently no difficulty was experienced in keeping both the adult and the embryos alive.

The shell was somewhat worn but appeared to be a right valve of the common *Dosinia coerulea* Reeve. There were 31 capsules in a group on the inner surface of the shell near the hinge line (Plate VI, fig. 7). Each capsule was oval in shape and composed of a transparent brown leather-like material, the surface of which was quite smooth and without any pattern. At each end, however, was a small circular spot. At one end the spot was nearer the upper surface than at the other end and formed a kind of operculum. This was forced open by the young leech when it emerged from the capsule. The capsules were very uniform in size and measured about 2·61 mm. long and 1·63 mm. wide.

During the 30 days the specimens were kept in sea-water in the laboratory, the adult leech usually rested near the capsules. Sometimes, however, it would leave them and move about in the water, later returning to the shell and coiling up in the attitude shown in Plate V, fig. 5.

Each capsule contained only one embryo. Seventeen young leeches completed their development and escaped from the capsules before the 26th November, 1940. They closely resembled the adult.

About ten species are now recognised as belonging to the genus *Pontobdella* (See Scriban and Autrum, 1934, p. (8) 338). These may be divided into two groups, viz., those in which the typical somite is triannulate and those in which it is quadrannulate. *Pontobdella verrucosa* belongs to the former group and is closely allied to *Pontobdella loricata*, Harding (1924, p. 490). The latter species, which is recorded from India, has, however, a clitellum composed of seven rings.

Moreover the figure which Harding gives shows the dorsal tubercles on the smaller annuli of a typical somite to be about equal in size, whereas in *P. verrucosa* the two middle tubercles are much smaller than the others on the dorsal side of the ring.

The type specimen of *Pontobdella verrucosa* and its egg-capsules will be lodged in the Australian Museum, Sydney.

Acknowledgments are made to the Trustees of the John Ralston Bequest, under whose auspices the above work was carried out.

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Plate V

Pontobdella verrucosa n. sp.

Fig. 1.—Diagrammatic lateral view of leech showing annulation of anterior somites and the position of the nerve ganglia. *n.g.* ganglion of somite XIV.

Fig. 2.—Dorsal view of two typical somites (XVIII and XIX) showing arrangement of tubercles.

Fig. 3.—Dorsal view of annuli 54-57 showing position of anus, (*a*).

Fig. 4.—Egg capsule viewed from above showing the aperture (*ap.*) through which the young leech has emerged and the disc (*d*) which it has forced out.

Fig. 5.—Leech in a coiled-up position over its egg-capsules.

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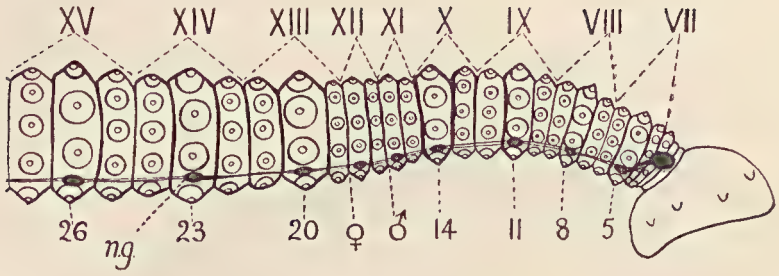
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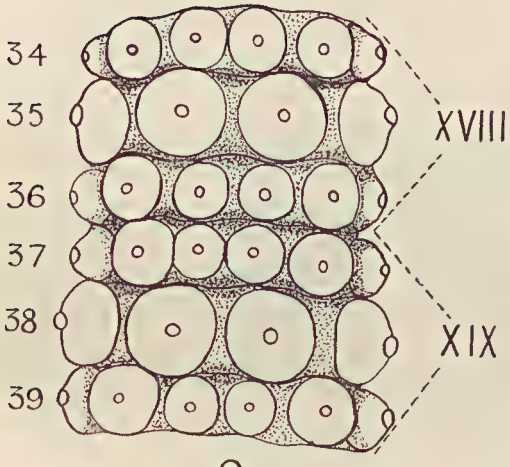
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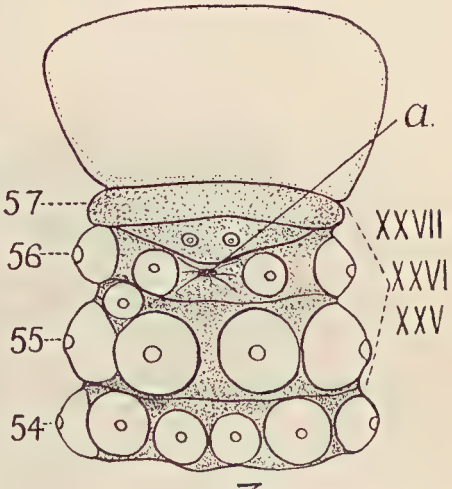
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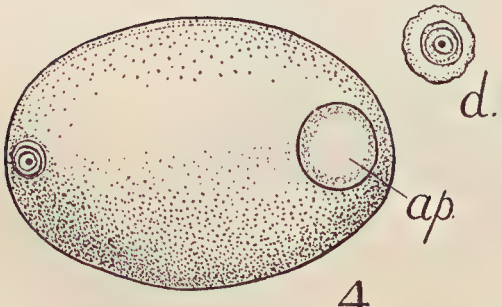
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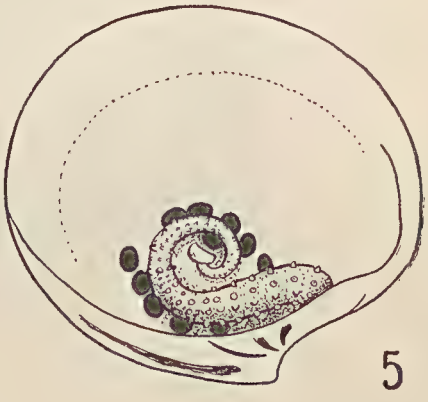

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Plate VI

Pontobdella verrucosa n. sp.

Fig. 6.—Photograph of leech (in alcohol). x 2.
Fig. 7.—Photograph of shell with egg-capsules of leech. x 3/2.

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Fig. 6.

Fig. 7.

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Observations on Some Tasmanian Fishes

Part V

By

E. O. G. Scott

(Read 10th November, 1941)

Plate VII

The present paper follows the general plan of previous contributions under the same title (1934, 1935, 1936, 1939): the term Fishes is interpreted broadly to include Selachians.

The dimensions standard length and total length are represented throughout by the symbols LS, LT, respectively.

Registration numbers are those of the Queen Victoria Museum, Launceston.

Family GALEIDAE

Genus **Carcharhinus** Blainville, 1816

Carcharhinus brachyurus (Günther, 1870)

(Plate VII)

?Galeolamna greyi Owen, *Descr. Cat. Osteol. Roy. Coll. Surgeons*, 1, 1853, p. 96. *?Id.* Whitley, *Rec. Aust. Mus. Sydney*, 1932, xviii, 6, p. 324. *?Id.* Whitley, *Fish. Aust.*, I, 1940, p. 102, fig. 88, no. 4 (not fig. 88, no. 5) and fig. 95; and p. 273, fig. 303 (not fig. 5).

Carcharias brachyurus Günther, *Cat. Fish. Brit. Mus.*, viii, 1870, p. 369 (specimens *c* and *d* doubtful). Not *carcharias brachyurus* Waite, *Rec. Aust. Mus. Sydney*, vi, 3, 1906, p. 226, pl. xxxix.

?Carcharinus macrurus Waite, *Rec. S. Aust. Mus. Adelaide*, III, 3, 1927, p. 224. *?Id.* McCulloch, *N.Z. Journ. Sc. Tech.* vi, 5-6, 1924, p. 261, fig. 4.

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?Carcharhinus macrurus Waite, *Rec. S. Aust. Mus. Adelaide*, III, 3, 1927, p. 224. *?Id.* Phillipps, *Mem. Aust. Mus. Sydney*, v, I, 1929, p. 10 (South Australian record only). Not *Carcharias macrurus* Ramsay and Ogilby, *Proc. Linn. Soc. N.S.W.*, (2), II, I, 1887, p. 163 and p. 624. Not *Carcharhinus macrurus* McCulloch, *Proc. Linn. Soc. N.S.W.*, XLVI, 4, 1921, p. 457, pl. XXXVII, figs 1-4.

?Carcharinus lamia Phillipps, *N.Z. Journ. Sc. Tech.*, VI, 5-6, 1924, p. 260 and fig. Not *Carcharhinus lamia* de Blainville, *Bull. Sci. Soc. Philom.*, 1816, p. 121.

Galeolamna brachyurus Whitley, *Fish. Aust.*, I, 1940, p. 102, fig. 97.

Record. A mounted Tasmanian *Carcharhinus* that has been in the Museum collections for over forty years is here provisionally determined as *C. brachyurus* (Günther).

First record for Tasmania.

Remarks. The systematics of this genus are in a parlous state. To the known handicaps that limit our knowledge of several species to information based on casts, disassociated jaws, or juvenile (even foetal) individuals, I may add two further complications—first, that information received (*in litt.*, 6/8/'37) from Mr J. R. Norman, Ichthyologist, British Museum, Natural History, leads me to suspect that Günther's type-specimens of *C. brachyurus* may not be conspecific; secondly, that tables of dimensions of specimens accessible to Waite, kindly furnished by Mr H. M. Hale, Director, South Australian Museum, Adelaide, appear to suggest that certain features commonly accepted as diagnostic criteria may be subject to a degree of individual variation hitherto unrecognized. In view of the urgent need for additional data, a description and figure of the present specimen are here given.

Description. Body moderate, fusiform, its depth at pectoral origin 7·9, at first dorsal origin (max. depth) 6·4, in length to origin of lower lobe of caudal; or 10·5, 8·6, respectively, in LT. Length to vent 1·5 in LT.

Head (to first gill-slit) 6·6 in LT; postorbital portion slightly, preorbital portion strongly, depressed. Snout 2·4 in head; obtusely pointed in horizontal plane; in profile acute, with tip about at, or slightly above, level of superior border of orbit. Preoral length 1·4 in width of mouth, which is 2·0 in head, and about twice length of mouth. A short indistinct groove extending forward on each side of gonidial angle. Nostril fairly large; near, but not quite reaching, inferolateral margin of snout; length to it 1·5 in preoral length, 1·3 in interarial distance. Eye about 2·5 in height of first gill-slit, about 10·6 in head; its anterior margin barely in advance of middle of mouth. Measured obliquely, distance from anterior margin of eye to tip of snout is about 1·3 in distance from posterior margin of eye to first gill-slit. Last two gill-slits above base of pectoral: fifth subequal to first, about 0·7 of third.

About 30 teeth in upper jaw (those in lower jaw inaccessible). Anterior teeth of upper jaw (Plate VII, fig. 3) as long (11 mm.) as high, erect, or slightly recurved: base compressed, half as high as long, its inferior margin so boldly excavated as to suggest incipient bifurcation: crown compressed, biconvex: both margins obtusely crenulated throughout their entire length; along borders of the crown the crenulations subrectangular, closely apposed, along borders of the base, particularly posteriorly, more distinctly separated, with a tendency to become bilobed or trilobed, and more acute.

Pectoral large, narrow, acuminate, with a pronounced postaxial internal flap; its length rather more than twice its maximum width, 3·7 times its width at middle, 1·2 in length to its origin, the latter being 1·8 times as far from tip of snout as from origin of first dorsal. First dorsal moderate, anterior border gently sigmoid, posterior angle produced as an acute lobe more than one-fifth as long as base of fin; its origin, located at 0·32 of LT, nearer to tip of snout than its termination is to origin of lower caudal lobe; its base half length of pectoral, 1·3 times its own vertical height. Interdorsal space 0·8 of length to origin of first dorsal, 3·3 times distance between termination of second dorsal and origin of upper caudal lobe. Second dorsal small, low, posterior angle produced into a slender lobe two-thirds as long as base of fin; its origin, located at 0·66 of LT, slightly behind level of anal origin; its base 2·5 in base of first dorsal, 2·2 times its own vertical height. Ventral subquadrangular; its origin, located at 0·49 of LT, slightly nearer to anal origin than to first dorsal origin; its base a little longer than its anterior border. Claspers subcylindrical, extending about two-thirds of the distance between their origin and anal origin. Anal small, having the appearance of being composed of

two lobes, the oblique, moderately acute anterior one about twice as wide as the slender, almost horizontal lanceolate one; its origin, located at 0·65 of LT, slightly nearer to origin of lower caudal lobe than to termination of ventral base; its base subequal to base of second dorsal, 1·8 times its own height. Caudal moderate, set (perhaps as result of mounting) only slightly obliquely to main axis of body: upper lobe originating at 0·77 of LT, about an eye-diameter behind origin of lower lobe; its terminal inferior flap, near free margin of which, at 0·6 of length of flap, the downwardly curving certebral column terminates, one-fourth length of lobe: lower lobe broad, obscurely pointed, with anterior border strongly convex, subequal to base of first dorsal, posterior border concave. Apparently a pit present at base of each caudal lobe.

Lateral line system appears to originate at level of middle of pectoral base, about one-sixth of depth of body below dorsal profile, and, proceeding caudad, sweeps gently and evenly down till on caudal peduncle it is equidistant from dorsal and ventral profiles; the oblique inferior tubules, of which there are 24 below first dorsal base, average twice as long as their interspaces.

General colour dark brownish grey (perhaps originally slatey) above, gradually lightening to palish grey below. No indications of dark tips to any of the fins.

Described and figured (Plate VII) from a mounted male specimen (Q.V.M. Reg. No. 962 *y*) of LT 2835 mm., and 2137 mm. long to origin of lower caudal lobe; caught in the River Tamar by G. T. Collins and R. J. Irvine in 1897.

Family MYLIOBATIDAE

Genus **Myliobatis** Cuvier, 1816

Myliobatis australis Macleay, 1818

Myliobatis australis Macleay, *Proc. Linn. Soc. N.S.W.*, VI, 2, 1881, p. 380.

This species is common, at any rate in summer, on Northern Tasmanian beaches, where it is a source of much inconvenience in seine-netting.

Females probably exceed males in size. Of seven specimens caught at Ulverstone in January, 1941, four females measured (width of disk, in mm.) 1022, 1050, 975, 866; three males 814, 780, 850. The smallest female and largest female thus exceeded the largest male by 2%, 24%, respectively, and the average value for females that for males by 20%. In both sexes length of tail slightly exceeds combined length of head and body, which is 0·5-0·6 of width of disk.

Family ANGUILLIDAE

Genus **Anguilla** Shaw, 1803

Anguilla australis Richardson, 1841

Anguilla australis Richardson, *Proc. Zool. Soc. London*, IX, 1841, p. 22.

A xanthic specimen of LS 525 mm., dorsal index (Schmidt, 1928) 3·8, was caught in the Macquarie River, at *Rokeby*, on 21st December, 1938, by Mr C. Willoughby. Xanthism is virtually complete, extending even to all the fins, and being not evident only in the eye; and is tolerably uniform, with, however, some tendency towards the assumption of a deeper, more orange tint above the lateral line.

Family AULOPIDAE

Genus **Aulopus** Cloquet, 1816

Aulopus purpurissatus Richardson, 1843

Aulopus purpurissatus Richardson, *Icones Piscium*, 1843, p. 6, pl. ii, fig. 3.
Aulopus milesii Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XXII, 1849, p. 385.

Record. A male specimen (Q.V.M. Reg. No. 1939. 119) of LS 279 mm. was caught at Ulverstone on 2nd November, 1939, and donated to the Museum by Mr F. Stephens. Two other individuals have since come to hand—a male (Q.V.M. Reg. No. 1940. 210), of LS 351 mm., from Blue Rock, Flinders Island (Mrs V. T. Hammond, 14th May, 1940), and a female (Q.V.M. Reg. No. 1941. 211), of LS 370 mm. from Rowella, West Tamar (Mr T. Cannon, 20th May, 1941).

Lord and Scott (1924, p. 35) note this species, but remark 'it is doubtful if' it 'can be classed as a Tasmanian form', and do not include it in their definitive list: not recorded as Tasmanian in the Check-List. The specimens here noted thus appear to provide the first definite records for Tasmania.

Remarks. Sexual dimorphism is well-marked. Taking the length of the 1st (simple) dorsal ray as unity, the relative lengths of the 2nd, 3rd, 4th rays are: smaller male 4·7, 4·3, 2·0; larger male 6·1, 3·0, 2·6; female 2·3, 2·0, 1·9. In the males the length of the two elongated rays (2nd, 3rd), relative to length of 1st ray, is thus 2·1 times the value for the female.

In the Ulverstone specimen the enlarged dorsal rays bear secondary rays, not unusual in this species, the 2nd ray (103 mm. long) giving rise, at 54 mm. from its base, to a sub-ray 7 mm. in free length, the 3rd ray (93 mm. long) giving rise, first, at 45 mm. from its base, to a double sub-ray 1·5 mm. in free length, and, secondly, at 45 mm. from its base, to a single sub-ray 7 mm. in free length: all these secondary rays originate from the posterior surface of the primary ray.

The female is of interest in having 14, instead of the usual 13, rays in the anal.

Family HYPOPLECTRODIDAE

Genus **Nannoperca** Günther, 1861

Nannoperca australis Günther, 1861

Nannoperca australis Günther, *Proc. Zool. Soc. London*, 1861, p. 116, pl. XIX, fig. 2.
Microperca tasmaniae Johnston, *Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883), p. 110; and *ibid.* 1890 (1891), p. 30.
Nannoperca tasmaniae Lord, *Pap. Proc. Roy. Soc. Tasm.*, 1922 (1923), p. 67. *Id.* Lord and Scott, *Synopsis Vert. Anim. Tasm.*, 1924, pp. 10 and 54. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1929, p. 157, *Id.* Scott, *Pap. Proc. Roy. Soc. Tasm.*, 1934 (1935), p. 66.

Status. In a key to the genus McCulloch and Waite (1918) failed to distinguish between *N. australis* and *N. tasmaniae*, and later Waite (1921) listed Johnston's species as a queried synonym of Günther's: the implied identity, probably based on the consideration of descriptions, is not accepted in the Check-List.

A comparison of Tasmanian specimens from Mella and Victorian specimens from Kororoit Creek, Seaholme, fails to reveal any constant differences of specific value.

Tasmanian Distribution. Johnston's original comment (1883) 'abundant in the rivers of the South and North Esk', virtually repeated in his memoranda redacted by Whitley (1929, *a*), was formerly interpreted by me as representing all that was known of the Tasmanian distribution, and I called attention (1936) to a record from the Rubicon River at Dunorlan: numerous specimens have since been collected (April, 1936) by Mr B. Burnley in drains at Mella. I find, however, I have overlooked a short paper by Johnston (1888) on the fauna of King Island, in which he incidentally notes this species 'also inhabits the waters of the northern rivers of Tasmania'.

Juvenile. Numerous juvenile specimens were obtained by Mr H. J. King in November, 1941 from a pool at Perth. In an individual of LS 11·1 mm. (Q.V.M. Reg. No. 1941. 356) assumption of the adult facies, including scale-formation, was virtually complete, save for the attainment of only an elementary stage of pigmentation, which permitted a clear view of the beating of the heart.

Family RHOMBOSOLEIDAE

Genus **Ammotretis** Günther, 1862

Ammotretis tudori McCulloch, 1914

Ammotretis tudori McCulloch, *Biol. Res. Endeavour*, ii, 3, 1914, p. 125, fig. 9.

Waite (1923) observes 'as five specimens are known, all exhibiting' the peculiarity that the first ray of the small left pectoral bears a large fleshy knob at its tip, 'it cannot be looked upon as an abnormality'. McCulloch (1914) thought it probable the species would 'be found to be sufficiently abundant to form a valuable addition to the list of edible Australian flounders'.

In the course of fairly extensive netting carried out at Ulverstone in January, 1941, I found *A. tudori* abundant, perhaps one in three specimens of flounders caught belonging to this species. Curiously enough, however, it apparently does not reach the local market; at any rate, I have never observed it displayed in Launceston fish-shops.

Family POMACENTRIDAE

Genus **Parma** Günther, 1862

Parma viola Whitley, 1929

Parma viola Whitley, *Mem. Queensl. Mus.*, IX, III, 1929, p. 231, pl. XXVIII, fig. 2.

Known only from the holotype, of LS 170 mm., forwarded in 1904 from this Institution to the Australian Museum, Sydney, where it remained (Whitley, 1929, *b*) for a third of a century labelled *Glyphisodon victoriae*. The receipt on 20th July, 1940 of a second specimen, of LS 154 mm. (Q.V.M. Reg. No. 1940. 292), caught at George Town, not only affords information on minor variations in proportion, but provides the first available data on coloration.

Proportions. Depth of body 1·9, of caudal peduncle 6·0, in LS. Head 3·7 in LS. Eye 1·2 in snout, 1·6 in interorbital space, 1·7 in head. Longest dorsal spine (5th, 6th) 1·8, longest dorsal ray (6th) 1·2, second anal spine 2·0, longest (8th) anal ray 1·4, longest (4th) pectoral ray 0·9, longest (2nd) pelvic ray 1·1, in head. Radial formulae agree with those of holotype.

Coloration. General colour of body above midlateral line bronzy brown, becoming purplish in parts, especially towards base of caudal; below midlateral line dingy pearl, with some purplish flushes. Head in general dark bronze; snout and nape dark brown, the latter almost black; scaleless marginal strip of preoperculum pearl, with pale bluish iridescence; operculum very dark brown anteriorly, becoming pearly brown at middle, posteriorly dingy silver with marginal streak of dark brown; lips dark brown; immediately below lower lip, a small patch of bright bronze, followed by two oblique chin-bars of silver, the first reaching nearly to angle of mouth, the second, whose width is subequal to its distance from the first, extending on to anterior portion of preoperculum; a hemispherical patch of pale copper arising from infero-anterior border of eye; a subrectangular patch of bluish purple shortly below, and partly in advance of, eye: pupil very dark blue, iris almost black; buccal cavity, including tongue, whitish.

Spinous dorsal: membrane pale bronze, becoming pale olivaceous towards free margin; spines rather darker. Soft dorsal: membrane dark olive; rays slightly lighter. Anal: membrane dark olive, with faint submarginal band of paler olive; rays rather lighter, five or six of the posterior ones with narrow dark-brown cross bar at two-thirds of their length; spines peacock blue. Caudal: membrane dark, somewhat yellowish olive, with a narrow band (marginal mesially, submarginal laterally) of lighter, more yellowish colour; rays about concolorous with membrane. Pectoral: membrane almost hyaline, slightly greenish above; rays olivaceous, the upper somewhat more greenish, the lower somewhat more yellowish. Pelvic: membrane brownish olive; rays mostly whitish, the anterior one somewhat dusky distally; spine dark peacock blue.

Family CORIDAE

Genus **Austrolabrus** Steindachner, 1883

Austrolabrus maculatus (Macleay, 1881)

Labrichthys maculata Macleay, *Proc. Linn. Soc. N.S.W.*, vi, 7, 1881, p. 89.

Record. A specimen (Q.V.M. Reg. No. 1939. 162), of LS 84 mm., LT 106 mm., was secured in a trawl at the mouth of the River Tamar, at a depth of 10-20 feet, by Mr E. H. Smith on 2nd December, 1939.

First record for Tasmania.

Coloration. The description of the holotype, four inches long, from King George's Sound, was drawn up after preservation of the specimen in spirits, and Macleay's (1881) colour-notes are meagre, as also are those of McCulloch (1913), who figures a specimen, 140 mm. long, from St Vincent's Gulf, South Australia. The following notes were made on receipt, shortly after capture, of the present specimen. General colour pale yellowish-green, with purplish tinges on and near head. Four or five dark brownish spots, about half size of scale, or less, above pectoral. On head, particularly on chin, which is bluish green, and on operculum, a few narrow reticulated reddish-brown markings: narrow dark bar immediately behind posterior border of preoperculum. Pupil dark greenish. Iris bluish green, with very narrow internal annulus of gold. Pectoral with membrane hyaline, rays pale purplish. Pelvic yellowish green at base, thereafter dusky purplish pink: whitish band on 3rd-5th rays. Dorsal with dusky, somewhat purplish areas, which, near middle of fin, cover virtually the whole of the membrane, and are reduced, in front and behind, to a subtriangular region (broadest proximally) between each

two adjacent rays; membrane between 1st and 3rd rays dark purplish-brown, small spots and slips of yellowish at bases and flanking basal half of spinous rays; a conspicuous dark-brown, almost black spot, about two-thirds diameter of eye, centring on proximal half of penultimate ray. Anal much like dorsal, but without anterior dark purplish-brown area, and with smaller hinder blackish spot, located here almost wholly on membrane between last two rays. Caudal with indications of dusky subvertical bars.

Family URANOSCOPIDAE

Genus **Kathetostoma** Günther, 1860

Kathetostoma laeve (Bloch and Schneider, 1801)

Kathetostoma laeve Bloch and Schneider, *Syst. Ichth.*, 1801, p. 47, pl. VIII.

Stomach-contents. A specimen of LS 246 mm. (Q.V.M. Reg. No. 1941. 91) netted near Rowella, River Tamar, by Mr T. Hinds on 27th February, 1941, had in the stomach two well-preserved specimens of *Ammotretis rostratus* Günther, 1862 of LS 70, 73 mm.; and two undigested, and two partly digested specimens of a flathead (*?Platycephalus bassensis* Cuvier and Valenciennes, 1829), the two former specimens measuring 60, 67 mm. in LS.

Fishermen state that this species secures its prey by leaping vertically, the leap frequently exceeding a foot.

Family SCORPAENIDAE

Genus **Neosebastes** Guichenot, 1867

Neosebastes nigropunctatus McCulloch, 1915

Neosebastes nigropunctatus McCulloch, *Biol. Res. Endeavour*, iii, 3, 1915, p. 157, pl. xxx.

Record. A beach-dried, but readily determinable, specimen of LS about 280 mm. was collected by the writer at West Ulverstone in December, 1938.

First record for Tasmania.

Neosebastes thetidis (Waite, 1899)

Sebastes thetidis Waite, *Mem. Aust. Mus. Sydney*, iv, 1, 1899, p. 100, pl. xx.
Sebastodes thetidis Waite, *Mem. Nat. Club N.S.W.*, 2, 1904, p. 47.

Not recognized as Tasmanian in the Check-List. Apparently, however, it should be included in the local list, being noted in the *Endeavour* Report as being 'very abundant in waters of 60-100 fathoms deep off the eastern coast of Tasmania' (McCulloch, 1915, *a*): see also Lord and Scott (1924).

Genus **Scorpaena** Linné, 1758

Scorpaena ergastulorum Richardson, 1842

Scorpaena ergastulorum Richardson, *Ann. Mag. Nat. Hist.*, IX, 1842, p. 217,

Appears in all local lists as *S. cruenta* Richardson, 1842 (*ex* Solander MS; New Zealand). New Zealand and Australian examples are considered to be conspecific; and *S. ergastulorum* has line priority.

Genus **Helicolenus** Goode and Bean, 1895

Helicolenus papillosus (Bloch and Schneider, 1801)

Synanceja papillosus Bloch and Schneider, *Syst. Ichth.*, 1801, p. 196: *ex Scorpaena cottoides* Forster MS.
Sebastes percoides Richardson, *Ann. Mag. Nat. Hist.*, IX, 1842, p. 217: *ex* Solander MS. *Id.* Johnston, *Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883), pp. 79 and 114: and *ibid.* 1890 (1891), p. 31. *Id.* Lord, *Pap. Proc. Roy. Soc. Tasm.*, 1922 (1923), p. 70. *Id.* Lord and Scott, *Synopsis Vert. Anim. Tasm.*, 1924, pp. 13 and 84.
Helicolenus papillosus McCulloch, *Mem. Aust. Mus. Sydney*, v, III, 1929, p. 385.

The above table of synonymy covers the principal local references: for extra-Tasmanian references see McCulloch (1929).

McCoy (1879) observes 'Rather rare on the Victorian coast'. Not at all uncommon in Launceston and Hobart fish-shops. Average total length 250-300 mm.

Usually figured (*e.g.*, McCoy, 1879; Waite, 1923) with dorsal fin terminating at last ray. I find, however, perfect individuals normally have half, or more, of last dorsal ray connected by membrane to caudal peduncle.

Family APLOACTIDAE

Genus **Aploactisoma** Castelnau, 1872

Aploactisoma milesii (Richardson, 1850)

Aploactis milesii Richardson, *Proc. Zool. Soc. London*, 1850, p. 60 Pisces, pl. I, figs 1-2.
Aploactisoma schomburgki Castelnau, *Proc. Zool. Acclim. Soc. Vict.*, I, 1872, p. 244.

The two features on which Castelnau found *Aploactisoma*, a series of palatine teeth, and two teeth on an anterior median longitudinal ridge on the upper jaw, have been shown to be non-existent (McCulloch, 1915, *b*). However, differences in cephalic architecture, notably the presence across the cheek of a series of protuberances, instead of a continuous ridge as in the extra-limital genotype of *Aploactis* Temminck and Schlegel, 1843, *A. aspersa* (Richardson, 1845), perhaps warrant generic distinction of the Australian fish.

Whitley (1933) has recognized a New South Wales and Victorian subspecies, *A. milesii horrenda*, distinguished from typical *A. milesii* from Western Australia (type-locality King George's Sound) and South Australia (type-locality of *Aploactisoma schomburgki* St Vincent's Gulf) by larger size ('up to nearly 7 inches', as against 'to 5 inches'), deeper body, villi blunt, papillose (fine and pointed in typical subspecies), colour more uniform and darker brownish than in *milesii*. A Tasmanian specimen of LS 130 mm., LT 160 mm. (Q.V.M. Reg. No. 1939. 147), caught at Low Head, in 5 fathoms, by Mr G. P. Smith on 26th November, 1939, is intermediate in character between the two subspecies, having the fine villi, and lighter brown coloration with indistinct darker spots and marblings of *A. m. milesii* (but not the whitish spots usually described as occurring in the caudal region), and the deeper body (depth at vent 3·8, maximum depth 2·7, in LS), and larger size of *A. milesii horrenda*.

Fin-counts of the vertical fins of the Tasmanian specimen fall outside the range found by McCulloch (1915) in an examination of 8 specimens from New South Wales, South Australia, and Western Australia, the dorsal formula being xiv, 16, the anal i, 14.

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Plate VII

Carcharhinus brachyurus (Günther, 1870)

A Tasmanian *Carcharhinus* (Q.V.M. Reg. No. 962 *y*) provisionally determined (see text) as *C. brachyurus* (Günther, 1870). Male. Total length 2835 mm. Caught in River Tamar by G. T. Collins and R. J. Irvine in 1897.

Fig. 1.—Lateral aspect. One-sixteenth natural size.
Fig. 2.—Ventral aspect of head. One-eighth natural size.
Fig. 3.—External aspect of two teeth from anterior part of upper jaw. Twice natural size.

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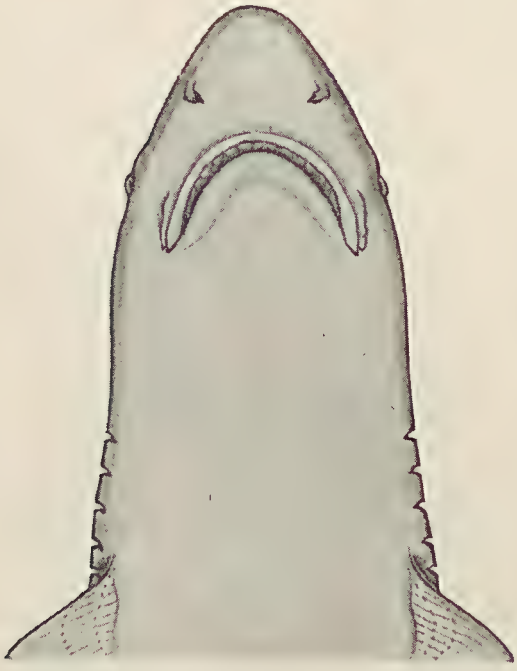

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NATIONAL MUSEUM OF V

Pap. & Proc. Roy. Soc. Tasmania, 1941 (15th June, 1942.)

The Nitrogen Bases in Tasmanite Shale Oil

By

R. F. Cane*

(Read 13th October, 1941)

Introduction and Historical

The type of nitrogen compounds produced during the retorting of oil shale, although essentially of a heterocyclic nature, depends on several factors, the chief of which are :—

(i) The rate of heating:
(ii) The retorting method:
(iii) The absence or presence of air.

Although these 'tar bases' are mainly derivatives of pyridine and/or quinoline, other compounds of a pyrrole nature have been reported to occur, for instance Petrie (1905) recorded the presence of pyrrole compounds in the oil obtained from the torbanites of New South Wales, and accounts of the shale oil from Colorado giving the same reaction have been reported by McKee (1925).

The first systematic work on the nitrogen compounds in shale oil was that of Williams (1854) on Dorsetshire shale. Williams wrote that they burnt with a smoky flame, possessed a very bad smell, were soluble in alcohol and gave a blue precipitate with cupric nitrate. He isolated pyridine and some of its lower homologues. Garret and Smythe (1902) working on Scottish shale oil succeeded in isolating and identifying seven members of the pyridine series by oxidation to the corresponding acids with potassium permanganate and by the preparation of the aurichlorides of the bases.

Robinson (1879) recorded the presence of nitrogen compounds in Scottish shale oil bases, occurring in the fractions boiling between 270° C. and 390° C. He proved that they were dicyclic compounds of the iso-quinoline series. In reference to the formation of salts, Robinson writes 'attempts were made to get crystalline salts from the mixed bases; the double chlorides of platinum, gold, cadmium, mercury, lead and zinc were tried but without success, only resinous sticky masses being obtained. The same failure in getting crystalline salts was experienced when the bases were treated with sulphuric, hydrochloric, nitric and oxalic acids'.

Kogerman (1931) gives a detailed description of the methods used to obtain the purified bases from Estonian shale oil, and makes the statement that 'The pure bases, separated from the shale oil, formed a reddish liquid with a quinoline-like odour, specific gravity—0·9731 at 15° and n_D—1·539/19°'. He also states that

* Chemist, National Oil Pty. Ltd., Sydney.

some of the higher bases failed to give crystalline salts, (cp. Robinson's remarks above), and, although he remarks that they belong to the pyridine and quinoline series, their presence was not confirmed. Eguchi (1927) has reported the presence of pyridine compounds in Fushun shale oil and identified methyl, dimethyl, and trimethylpyridines.

From the above brief summary it can be seen that aliphatic nitrogen compounds do not play an important role in the tar bases present in shale oil. These bases are, practically without exception, heterocyclic in structure and consist of alkylated pyridines and quinolines. The bases found in Tasmanite shale oil were typical of the above, members of the monocyclic and dicyclic series having been identified. However, a second type of base was found to be present, apparently belonging to the 'naphthenic base' group already discovered in Californian petroleum.

Experimental

The material used in this investigation was not a representative crude oil in the true sense of the word, because very gentle pyrolysis was used in its production, the temperature being kept at all times below 420° C., a description of the properties of this oil has been given elsewhere by Cane (1941). The amount of tar bases present in the oil as determined by a modification of the Universal Oil Products Laboratory method No. C-78-40 was 3·2 per cent, while an examination of 10° C. cuts showed zero per cent in the lower fractions, with increasing amounts to nearly six per cent in the higher ones. The oil was extracted with successive batches of 10 per cent sulphuric acid, the acid washings removed, bulked, and then made alkaline with caustic soda, the supernatant oily layer allowed to settle on the top and then removed. The united bases were extracted with anhydrous petroleum ether and the etherial layer concentrated. The bases were again converted into their sulphates and the aqueous layer washed with petroleum ether to remove traces of hydrocarbons, and finally the purified bases liberated with dilute caustic soda solution. The isolated bases were orange in colour with a distinct greenish fluorescence, and possessed the following properties:—

Specific Gravity @ 20° C.	0·9717
Refractive Index @ 20° C.	1·5242
Nitrogen	8·41%
Sulphur	0·27%

Their smell was characteristic of the shale bases; i.e., a mixture of pyridine and quinoline together with a faint peppermint smell. The smell of the bases lingered on the hands, even after several washings, and the physiological action was quite pronounced, the vapour producing the most acute headaches across the eyes and at the nape of the neck.

General Reactions of the Bases

(i.) No carbylamine reaction.

(ii.) No crystalline quaternary ammonium salts with methyl iodide, but after standing for six months in a sealed tube a dark red tarry solid was formed.

(iii.) When diazotised and subsequently coupled with beta-naphol a dark green material was precipitated, and, when this was washed with sodium carbonate solution, a portion of the precipitate dissolved to form a deep red solution which dyed filter-paper orange. The residue from the sodium carbonate treatment was a green powder.

(iv.) No Rimini's reaction and a very faint and doubtful Liebermann reaction.

(v.) A deep blue precipitate was formed with cupric nitrate.

(vi.) When the bases were reduced with sodium amalgam and alcohol for about 150 hours, a white water-soluble crystalline substance was precipitated.

Distillation of the Bases. The purified and dehydrated bases were distilled several times in all glass apparatus of special design, the column was silvered and vacuum jacketed, and the packing consisted of single turn wire helices. The following were the distillation results:—

Fraction No.	Boiling Range ° C.	Density @ 20° C.	Refractive Index @ 20° C.	Average Mol. Wt. (1).	Nitrogen. %	Vol. %
B1	165-213	0·9270	1·5070	128·3	10·89	5·7
B2	213-238	0·9518	1·5128	158·1	10·07	32·5
B3	238-250	0·9778	1·5299	169·9	9·39	22·0
B4	250-270	0·9803	1·5200	174·9	9·10	13·0
B5	270-290	0·9891	1·5349	171·8	8·89	13·7
B6	....	....	....	Residues and loss		13·1

The first fractions were colourless, but developed a light yellow colour on standing, while the higher fractions varied progressively from light yellow to a deep orange shade. All fractions deepened on standing, and it is interesting to note here the observations of Delaby and Hiron (1930) 'The alkyl quinolines are liquids of strong odour, light yellow in colour, and the colour becomes deeper, according to increasing molecular weight. Ethyl quinoline is nearly colourless when freshly distilled and under the same conditions butyl quinoline is straw yellow, but finally it assumes a brown red colour which deepens according to the time of preservation'.

Fraction B1.—When closely fractionated on a semi-micro scale, the following results were obtained. In this work the criterion for the acceptance of any one substance from the point of view of boiling point was that all of this fraction must distill between the boiling limits of 1° C.

Fraction No.	Boiling Point.	Specific Gravity @ 18° C.	Refractive Index @ 20° C.	M.P. of Picrate.	Nitrogen. %
B1 (i)	173·2	0·9181	1·4984	154	11·33
B1 (ii)	198·4	0·9390	1·5004	N.O. (2)	10·91
B1 (iii)	206·4	0·9503	1·5054	N.O.	10·24

The above picrate and all others in this paper was obtained in the following manner:—The base was dissolved in 35 ml. of acetic acid, and to it was added two grams of picric acid contained in 5 ml. of 50 per cent acetic acid. When the crystals were deposited they were centrifuged from the mother liquor and crystallised from alcohol, washed, dried, and the melting point found.

(1) The molecular weight was determined by the cyrocopic method, using cyclohexane as the solvent, Muscarelli and Benati (1909).

(2) Not obtainable.

Analysis of the results of Fraction B1 (i) agree closely with reported ones for γ-collidine (2, 4, 6, trimethylpyridine), but it must be kept in mind that different authorities give very divergent values for these constants, and it has been noticed that they even differ by as much as 6° C. in the case of the boiling points of uncommon derivatives.

Portion of this fraction was oxidised with potassium permanganate in a normal laboratory manner, and among the oxidation products the presence of trimesitic acid was confirmed.

Trimethyl pyridine has already been found in Fushun shale oil by Eguchi (1927) and also has been isolated from lignite tar by Krey (1895). No success was obtained in the analysis of the Fraction B1 (ii). The preparation of crystalline precipitates was rendered impossible on account of the formation of thick orange tarry masses when the bases were treated in accordance with the technique described above. Every case resulted in the formation of this resinous mass, no matter how the formation of crystals was promoted, and it is interesting to note that Robinson made the same observation. He tried many inorganic salts, but the only result was 'resinous, sticky masses being obtained'. From later researches it seems probable that Robinson's, and the present, results were due, in part, to insufficient purification, but even Baily (1930), in the last few years, has had the same difficulty in the elucidation of the structure of the tar bases occurring in Californian petroleum. The last fraction, together with Fraction B2, seemed to be a transition stage between, or a mixture of, the mono-cyclic and di-cyclic bases. That the next fraction was of quinolinic nature is indicated by the sudden drop in nitrogen content and rise in molecular weight. An analysis of the boiling points and refractive indices might indicate the presence of hydrogenated quinolines, for as far as could be ascertained from the available literature none of the simpler alkyl pyridines have boiling points approaching any of the above. Even assuming that this fraction was composed of a complex mixture of highly alkylated pyridines, the refractive index is much too high to allow this consideration, e.g., propyl pyridine (b.p. 178° C.) has a refractive index of only 1·4934. Similar statements could be made with regard to the presence of hydro-quinolines. No less than nine alkyl deca- and tetra-hydro quinolines have boiling points approaching the above. It may be assumed that, if these fractions contain hydro-quinolines at all, the refractive index would surely rise as the fraction was reduced, and with this end in view a representative sample was dehydrogenated according to the procedure of Diels and Karstens (1927):—Five gms. of the base and 7 gms. of powdered selenium were heated for 38 hours at a temperature of 185 $\pm$ 1·5° C. and the change in refractive index noted.

Refractive index before treatment	1·5126
Refractive index after treatment	1·5128

From a consideration of the hydro-quinolines, it can be calculated that the removal of four hydrogen atoms would cause an increase in the refractive index by an amount varying between 0·038 and 0·032, an increase which could be easily determined by refractrometric methods.

Fraction B3.—From this fraction onward it can be seen that there is a drop in nitrogen content, while the refractive index and molecular weight still rise. The per cent of nitrogen in trimethyl quinolines is 8·9 and molecular weight 171·1, which are in the range of the above fraction, but there are two important properties which require explanation, i.e., the low refractive index and density.

From the preliminary work on a bulk sample, the presence of quinolines was confirmed, but members of the series boiling in this range have refractive indices

greater than 1·58. It was shown, by treatment with selenium as before, that hydro-quinolines were not causing this discrepancy.

The work of Baily and his collaborators on the nitrogen-containing bases in Californian petroleum, has shown that another important type of tar base (naphthenic base) may occur, and it seems probable that similar compounds occur in Tasmanite shale oil. They are apparently tri-cyclic in structure and contain a piperidine nucleus. Baily's process of a cumulative extraction was applied to a representative fraction boiling between 240° C. and 290° C. It was dissolved in 1 : 1 aqueous hydrochloric acid and treated with chloroform according to the procedure developed by Baily. The aqueous layer containing the hydrochlorides of the quinolinic bases was washed with decreasing amounts of chloroform; the chloroform layer containing the naphthenic bases with decreasing amounts of water. Under this treatment the refractive index of the 'aromatic section' rose from 1·5321 to 1·5845, and the specific gravity increased to nearly unity after five stages of extraction.

From this it can be seen that we are dealing with exactly the same set of conditions experienced by Baily. Furthermore, the values of the refractive index and density are now within the range of the tri-methyl quinolines.

The extracted bases consisted of a sticky, semi-crystalline mass of light yellow colour with a greenish yellow fluorescence. The chloroform washings of the 'non-aromatic' bases were treated so as to isolate the free bases and their general properties found. They were brownish red in colour, with a blue fluorescence and refractive index of 1·4985. They gave the normal reactions characteristic of pyrrole compounds. It is believed that the structure of these bases is very complex, and no attempt was made to elucidate their structure. The quinolinic bases were converted into their picrates in solution buffered with sodium acetate, purified, and then heated with ammonia, from which the bases separated out as nearly solid masses. The bases were further purified by treatment with acetone, and then very carefully distilled in vacuo.

Fraction No.	Temperature Range.	Refractive Index @ 20° C.	Density @ 15° C.	Molecular Weight.	Nitrogen. %
C1	244-245	1·5983	1·0641	142·0	9·89
C2	271-273	1·5903	0·9953	163·8	8·77
C3	277-279	1·5832	0·9307	177·4	8·01
C4	284-285	1·5742	0·9502	179·7	7·49

Analysing these results it can be seen that the first two fractions appear to contain methyl and di-methyl quinolines respectively, although their presence could not be confirmed. Tri-methyl quinoline was isolated from Fraction C3. This will be discussed later.

Great uncertainty exists with regard to the characteristics of these bases, and widely divergent values have been reported with regard to the higher alkyl quinolines; for example, four different values for the boiling point have been reported recently of 2-3-dimethyl quinoline varying between 261° and 273° C., so that in these analyses it has been attempted to class the quinolines according to the number of alkyl groups rather than to isolate individual compounds.

The Presence of the Quinoline Ring in the Higher Bases

A small quantity of the 'non-extracted' bases corresponding to Fraction C2 (no more of the purified substance being available) was oxidised very carefully with 2 per cent aqueous alkaline potassium permanganate solution for 15 hours. Quite an amount of trouble was caused by the bumping of the solution on account of the precipitated manganese dioxide. A small air leak introduced into the solution helped to minimise this difficulty and also served to inject sufficient permanganate solution during the operation. The resulting solution of pale stone colour was filtered and rendered acid. This was slowly distilled and the vapours condensed into aqueous ammonia solution, and the volatile organic acids examined (I.), the non-volatile matter was extracted with benzene in a Soxhlet extraction apparatus (II.), and the residue recrystallised from hot water (III.).

The Volatile Organic Acids

The ammonium salts of the volatile organic acids were analysed, only the presence of acetic acid being confirmed in this solution, although a slight reducing action was observed, perhaps indicating the presence of formates, although they could not be confirmed.

The Benzene Solubles

The yellowish non-volatile mass was placed in a Soxhlet thimble and extracted with benzene for 38 hours, the residue being left in the thimble and extracted with water (III.). The benzene solution was evaporated in vacuo. All attempts to elucidate the structure of this portion were unsuccessful, but results tended to prove that this was due to the presence of the naphthenic bases, which, according to other investigators, are extremely stable, both to neutral or alkaline permanganate oxidation.

The Water Solubles

The water soluble material was concentrated and silver nitrate added; this caused an immediate dirty white precipitate, which was filtered off and purified. The amount of silver in the silver salt amounted to 58·6. Another portion of the silver salt was treated so as to liberate the free acid, no attempt being made to concentrate this on account of the difficulties encountered by Hantzsch (1882). The reaction with ferrous sulphate indicated a carboxylic acid in the α position. When this acid was distilled to dryness with lime, the odour of pyridine was observed.

It has been shown that the nitrogenous base present in the 271°-273° boiling range leads, on oxidation, to the production of pyridine carboxylic acids and, from the percentage of silver in the silver salt and basicity measurements, gives a molecular weight of 231·6 for the acid: this approximates fairly closely with methyl pyridine tri-carboxylic acid. Two of these carboxylic groups can be accounted for by the disintegration of the 'benzene' half of the molecule. This shows that there are two side chains in the 'pyridine' half of the molecule, one of which is obviously a methyl group.

From a study of the molecular weights of the base, it can be seen that we are dealing with either an ethylmethyl or trimethyl quinoline with perhaps a small percentage of higher homologues. However, assuming that trimethylquinoline is the major component, then there must be only one methyl group in the benzene half of the molecule. When the acid was heated and then coupled with resorcinol, a deep red substance was formed which had a distinct colour change from acid to alkaline solution; this compound, assumedly of the phthalein type, could only aside from an acid anhydride, necessitating two carboxyl groups in the ortho position to one another. Further proof of this orientation lies in the fact that it

was found, by using formaldehyde, that two and not three hydrogen atoms were replaced by carbinol, which, according to the results of Königs (1899), will only occur when the ortho position to the methyl radicle is substituted, that is, if the benzene ring is not acting as the ortho substituent.

Phthalone formation, requires a methyl or methylene group in the α or γ position. A small amount of the base was heated with phthalic anhydride and zinc chloride for five hours at 165°; the resulting compound was a fine deep-red solid, which dissolved in boiling alcohol to give a crimson-orange solution.

The lack of formation of quarternary ammonium salts by methyl iodine may well be explained by reference to the results of Decker (1905), who found that ortho substituted quinolines exhibit steric hindrance, in that they do not form quarternary ammonium compounds with iodides. Oxidation of the base with chromic acid gave brownish needles, soluble in hot water. which sintered about 245°. The distillation of the barium salt gave a liquid (n_D^{20}-1·6053), which on oxidation with potassium permanganate, and distillation of the acid thus produced, gave quinoline itself.

Summary of the Basic Bodies

The only base isolated in the lower fraction was trimethylpyridine, the presence of which was confirmed by oxidation to the corresponding acid.

The compounds in the higher fractions consist, in the main part, of tertiary bases of the quinoline series, but results have shown that a second type of basic substance occurs, which possesses a low refractive index and probably contains a pyrrol nucleus in its structure.

The presence of hydrogenated quinolines was shown to be impossible from a study of the refractive indices before and after dehydrogenation experiment with selenium.

The presence of the quinoline ring was confirmed by oxidation, and from this it was shown that the alkyl radicles attached to the nucleus were nearly all methyl radicles.

The orientation of the methyl radicles in one fraction was elucidated, and it was found that one of them was in the 1; position, the other in the 2; position. The remaining radicle was in either the 5; or 8; position.

This investigation was carried out in the Department of Chemistry in the University of Tasmania, during the tenure of a Commonwealth Government Research Scholarship (1938 and 1939).

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A Study of the Carbonization of some Tasmanian Timbers

By

J. C. Jaeger

and

Cynthia M. Johnson

1.—Introduction

Most experiments on the carbonization of wood in closed retorts have been designed for the study of the distillates, and thus have usually been made on wood of irregular sizes, the temperature in the retort, but not in the wood, being measured. If it is a question of the production of good charcoal, it is desirable to know as much as possible about the progress of the carbonization reaction in the wood and the effect on the charcoal of such factors as log size and external temperature conditions. The present experiments have been made from this point of view on single cylindrical logs of varying sizes under controlled external conditions.

It is well known that the carbonization reaction (1) is exothermic and sets in at a temperature in the neighbourhood of 300° C. Gaseous and condensible distillates are given off during the reaction with a violence which will be shown below to vary greatly with the size of the log and the external conditions. If the heating is continued after the initial violent reaction is over, there is a steady, slow, evolution of volatile matter, accompanied by shrinkage of the charcoal, but there is no considerable change in the structure or hardness of the charcoal. Thus the final product may be regarded as produced in two stages, (I.) the carbonization reaction, and (II.) subsequent heating. In the experiments described below these two stages will be separated as far as possible. In §§ 2-4 the external temperature conditions are arranged so that their influence is small compared with that of the heat generated by the carbonization reaction itself, while cases in which the influence of external conditions predominates are considered in § 5. In §§ 2, 3, 5 only the temperatures developed are discussed, their influence on the nature of the charcoal is considered in § 8. The yield and nature of the species charcoal produced under low temperature conditions is given in §§ 4 and 8. The effect of continued heating after the carbonization reaction is over is considered in §§ 6-8.

The whole of §§ 2-9 refer exclusively to 'dry' wood, i.e., to wood of moisture content of, say, 25 per cent or less; the behaviour of green wood is discussed in § 10.

(1) Throughout this paper 'carbonization reaction' is taken to refer to the violent initial reaction and not to the complete reaction giving the final charcoal. It is also convenient to speak of it as setting in at a definite temperature.

2.—The Temperatures Attained During the Carbonization Reaction

In the present experiments wood is carbonized in single cylindrical pieces of varying diameters up to 7″ and of lengths up to 2′. These are heated in an electrically heated retort, and the temperatures at various points of the log are measured by thermocouples. The gases given off are passed through a water-cooled condenser, and the quantities of condensate and of non-condensible gas are measured. The heating has usually been made in two stages, the first at a low current which gives a constant temperature of about 200° C. through the log after twelve hours; the current is then increased giving a slowly rising external temperature. This procedure has been adopted partly for convenience and partly to eliminate the effect of moisture and to treat all logs as far as possible on a standard basis.

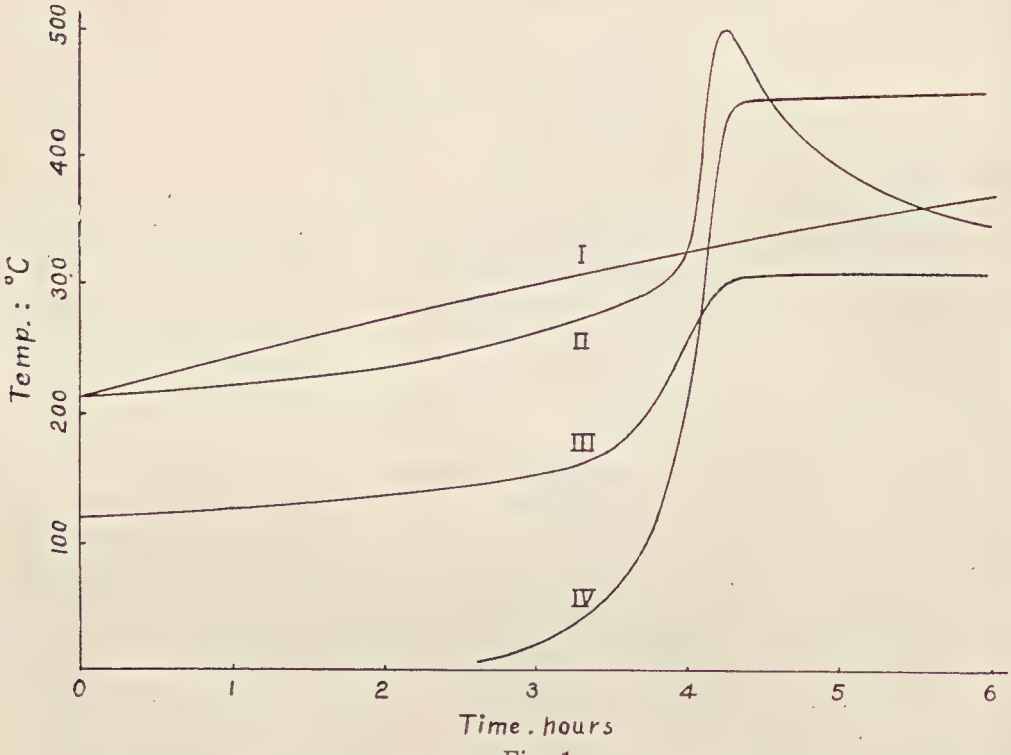

Fig. 1.

Typical behaviour under these conditions is shown in fig. 1 for a 6″ diameter log of *E. linearis*, 13″ long, weight 13·74 lb., moisture content 18·5 per cent. Curve I shows the retort temperature and Curve II the temperature at a point on the axis of the cylinder 6″ from one end. The volumes of condensate and non-condensible gas given off are shown in Curves III and IV respectively; the total volume of condensate is 2·88 litres, and the total volume of gas given off is 452 litres. Although the observed temperatures might be expected to be affected by cracking in the wood or in the charcoal, the curves of fig. 1 are quite characteristic and surprisingly reproducible; as an example of this the maximum temperatures recorded in five experiments under the same conditions on 6″ logs of *E. linearis* were 502, 500, 500, 495, 492° C.

It will be seen that, when the external temperature reaches a value in the neighbourhood of 300° C., the rate of flow of distillate increases and evolution of gas commences; these both fall off very sharply at the conclusion of the reaction. The most interesting point about fig. 1 is the magnitude and steepness of the temperature rise; these are greatest at the centre of the log, but they do not vary much over the cross-section of the log, except close to the surface; this matter is discussed in detail in § 3.

If the external temperature of the log is raised steadily, instead of in two stages as above, there is very little difference in the behaviour provided the external rate of increase of temperature is of the order of those in fig. 1. In the early stages of the heating the temperature at the centre of the log will lag considerably behind the outside temperature, so that, when carbonization commences, the rise of the internal temperature to its maximum will be steeper than that shown in fig. 1. The maximum temperature attained is unaffected.

TABLE I

Diameter (inches).	7	4·5	3	2·6	2·2	1·8	1·2
Max Temp. (° C.)	500	500	468	435	401	351	321
Max. Rate of Increase of Temp. (° C./min.)	30	30	21	16	8	4	1·2
Average Volatile (%)	25	26	29	30	32	39	42

For the same external conditions the maximum temperature attained in the log varies with the diameter of the log, this effect is shown in Table I for *E. linearis* carbonized under the standard conditions described above. The cause of this effect cannot be settled until a more careful study of the thermal constants of charcoal has been made, it must be due in part at least to the relatively greater loss of heat from the smaller logs to the surroundings. The volatile contents given in Table I, and the nature of the charcoal produced, will be discussed in §§ 6 and 8. Of course not only the maximum temperatures, but also the maximum rates of increase of temperature and of flow of distillate, in fact the violence of the reaction, increase with increase of diameter.

3.—The Progress of Carbonization Through the Log

Carbonization will set in at the point of the log which first attains the carbonization temperature; heat will be liberated at this point, and will be propagated through the log. For a long cylinder with external temperature constant along its length, the propagation will be radially inwards; this behaviour is approximated to if the outside of the log attains its carbonization temperature while the internal temperature is still fairly low. If there is not much temperature variation within the log, as is the case under the standard conditions of § 2, carbonization will commence at the hottest point of the length of the log and there will be a combination of radial and longitudinal propagation. This is shown in fig. 2 for a 6″ log of *E. linearis*. In this experiment the temperature at the centre of the retort was a little higher than at the ends, and the temperature maximum is propagated from the centre towards the ends.

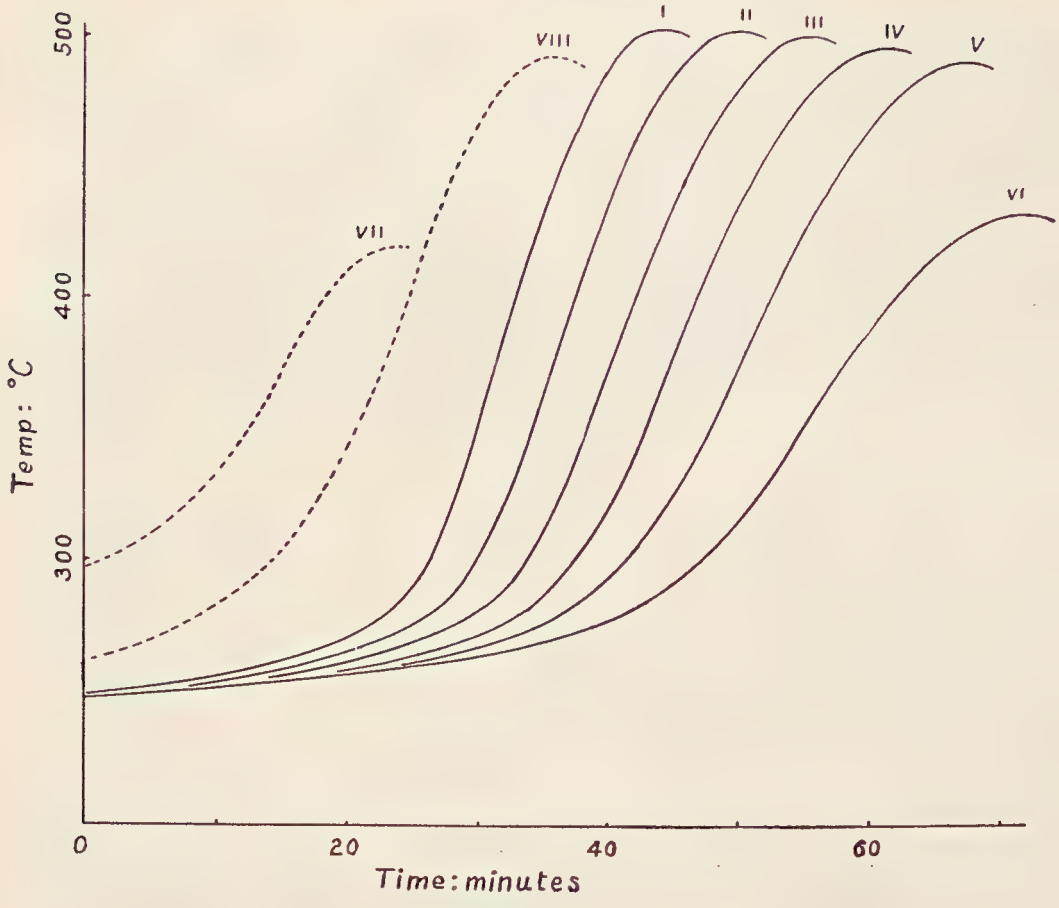

Fig. 2.

Curves I-VI show respectively portions of the temperature curves for points on the axis of the log distant 5½", 4½", 3½", 2½", 1½", ½" from the end of the log; the isothermals can be seen to be travelling at a rate of about 1" in 4 minutes. Curve VII shows the temperature at a point just under the surface and 5½" from the end; the temperature rise here is less in magnitude, and earlier, than at the corresponding point on the axis. Curve VIII shows the temperature at a point ¾" below the surface and 5½" from the end; here, already, the maximum temperature attained is almost equal to that on the axis.

4.—Behaviour of Different Timbers

Behaviour similar to that of fig. 1 for *E. linearis* is shown by all the timbers which have been examined. The variation between different species carbonized under the same conditions is shown in Table II. All timbers have been carbonized in cylinders 3" diameter and 15" long under the standard conditions referred to in § 2, the external rate of increase of temperature being about 0·5° C. per minute. The first column shows the maximum temperature attained on the axis, the second column its maximum rate of increase in ° C. per minute. The third column shows the maximum rate of flow of distillate expressed as the percentage given off per minute of the total distillate (from the dry wood). The yields of charcoal, stated

as the amount of dry charcoal of 15 per cent volatile (1) as a percentage of the dry weight of wood, are given in the last column. The number of experiments on which Table II is based varies from about 30 on *E. linearis* and *E. regnans*, which, with *Acacia dealbata*, have been most carefully studied, to one or two for the less important timbers. It is seen from Table II that all timbers examined give yields of the same order. Figures obtained for the same timber carbonized in different ways, and for green and dry timber (corrected as above for differences in volatile content), do not differ by more than two or three per cent.

TABLE II

Common Name.	Botanical Name.	Max. Temp. ° C.	Max. Rate of Increase of Temp.	Max. Rate of Flow of Distillate.	Yield. %
White Peppermint	*Eucalyptus linearis*	455	22	2·1	37
Black Peppermint	*E. salicifolia*	468	19	2·2	39
Stringybark	*E. obliqua*	472	22	2·1	36
Swamp Gum	*E. regnans*	465	19	2·2	36
White Gum	*E. viminalis*	463	14	2·8	36
Cabbage Gum	*E. pauciflora*	468	18	1·6	38
Black Gum	*E. ovata*	455	9	2·1	38
Blue Gum	*E. globulus*	435	16	1·3	36
Gum-topped Stringybark	*E. gigantea*	428	8	1·5	39
Victorian Red Gum	*E. rostrata*	364	3·5	0·9	43
Silver Wattle	*Acacia dealbata*	450	20	3·1	34
Black Wattle	*A. decurrens*	450	25	2·8	34
Prickly Wattle	*A. verticillata*	465	20	3·0	35
Blackwood	*A. melanoxylon*	442	12	2·0	38
Myrtle	*Nothofagus Cunninghamii*	430	8	2·0	35
She Oak	*Casuarina quadrivalvis*	450	13	2·1	36
Bull Oak	*C. suberosa*	441	13	2·0	34
Sassafras	*Atherosperma moschatum*	440	12	2·2	34
Manuka	*Melaleuca* sp.	440	15	1·8	32
Wild Pear	*Pomaderris apetala*	414	8	3·4	34
Currijong	*Plagianthus sidoides*	460	24	3·5	34
Redwood	*Beyeria viscosa*	405	8	3·0	37
Honeysuckle	*Banksia marginata*	366	4	1·8	37
Dogwood	*Bedfordia salicina*	410	7	1·5	35
Tea Tree	*Leptospermum* sp.	....	....	....	32
Leatherwood	*Eucryphia Billardieri*	....	....	....	35
Celerytop Pine	*Phyllocladus rhomboidalis*	....	....	....	35

It will be seen that, while all timbers behave in the same way, there are considerable differences in the violence of the reaction. Roughly it may be said that high values of the maximum temperature, the maximum rate of temperature rise, and the maximum rate of flow of distillate are associated and form a 'violent' reaction; while low values, again, are associated to form a 'quiet' reaction. Thus

(1) The final temperature in these experiments is 350° C., and the volatile contents range from 25-35 per cent. The yields have all been reduced to 15 per cent volatile in Table II.

E. linearis shows a typical violent reaction, and *E. rostrata* [1] a very quiet one. A quiet reaction usually gives a solid charcoal in very large pieces; the charcoal from a violent reaction is much more broken. This question will be returned to later.

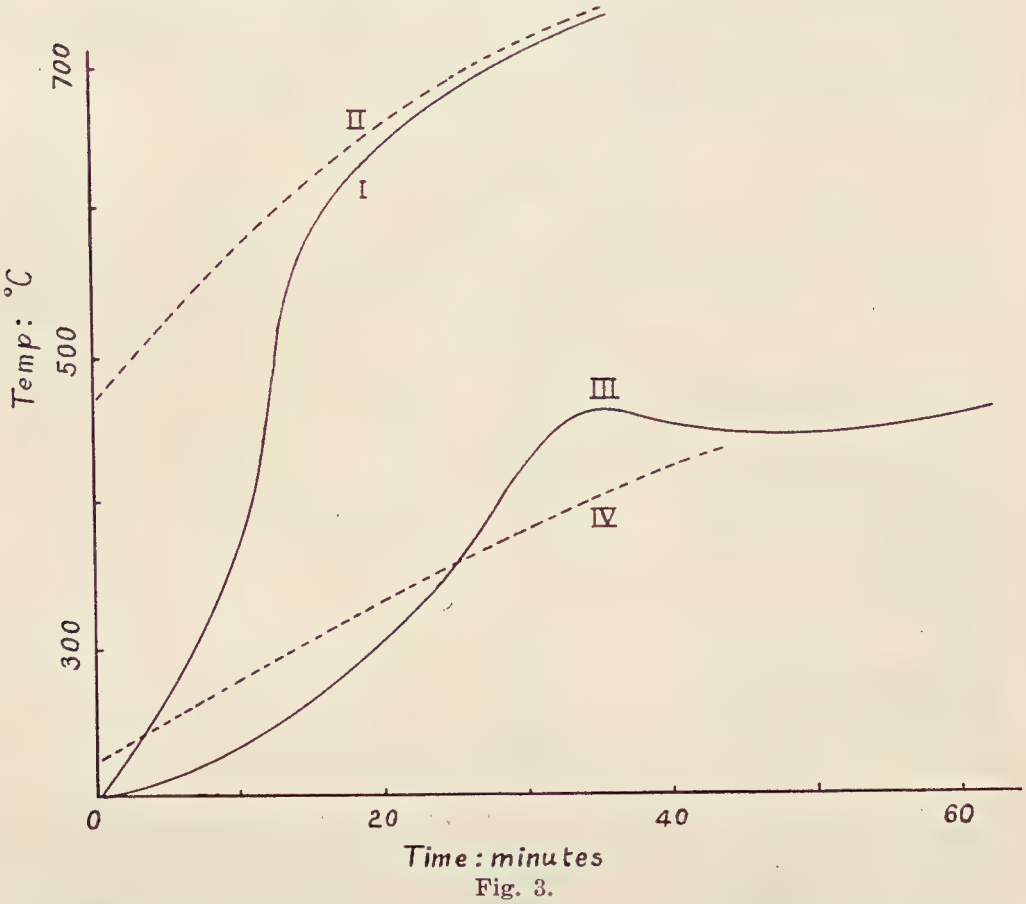

Fig. 3.

5.—The Temperature in a Rapidly Heated Log

If the external temperature of a log is raised rapidly, instead of slowly as in §§ 2 and 3, there is still an increase of temperature in the interior due to the heat evolved during carbonization, but the maximum of fig. 1 is less pronounced or disappears. This is illustrated in fig. 3 for *E. linearis* 2" diameter; Curves I and III are portions of the axial temperature curves corresponding to the external temperature variations II and IV respectively. In Curve I the characteristic maximum of fig. 1 has disappeared; in Curve III it is still present, though not so marked. The maximum rates of increase of temperature are greater than those of Table I, their values being about 80° C. per minute for Curve I and 20° C. per minute for Curve II.

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[1] Throughout this paper *E. rostrata* refers to a single piece of the timber sent from the mainland. It is discussed partly because the standard testing charcoal is made from this timber, and partly because of its extreme behaviour. The piece in question is apparently from the centre of a large tree and is very short in fibre.

6.—The Volatile Content

It has been shown above that the violence of the carbonisation reaction may vary very considerably with the log size and the external temperature conditions. If the charcoal is allowed to cool immediately the reaction is over, it would be expected that the product of a violent reaction would have a lower volatile content than the product of a quiet reaction. That this is the case is shown by the figures of Table I; in all cases the retort is allowed to cool (taking about 12 hours) after the reaction is over. Under these conditions, also, there is a noticeable variation of volatile content over the cross-section of the timber; its value is least at the centre and greatest at the outside. Typical figures for a 6″ log of *E. linearis* are: outside 31 per cent, mid-radius 26 per cent, on the axis 24 per cent. Reasons for this variation are presumably (I.) that the temperature rise is greatest on the axis, (II.) that the wood on the axis is the last to carbonize, and (III.) that cooling is slower on the axis.

If heating is continued after the carbonization reaction is over, volatile matter continues to be evolved slowly, so that, if the charcoal is given a period of soaking at a final temperature, before being allowed to cool, the volatile content of the final product may be expected to depend on this temperature as well as on the violence of the reaction. Clearly, if the final temperature is less than the maximum temperature attained during carbonization, the resulting volatile content will depend in a complicated manner on both these temperatures and cannot be correlated with either. However, if the final temperature is greater than the maximum temperature (1), and the charcoal is given a reasonable soaking at the final temperature, a volatile content is attained which depends mainly on the final temperature. The following figures for *E. linearis* with a final temperature of 500° C. will illustrate

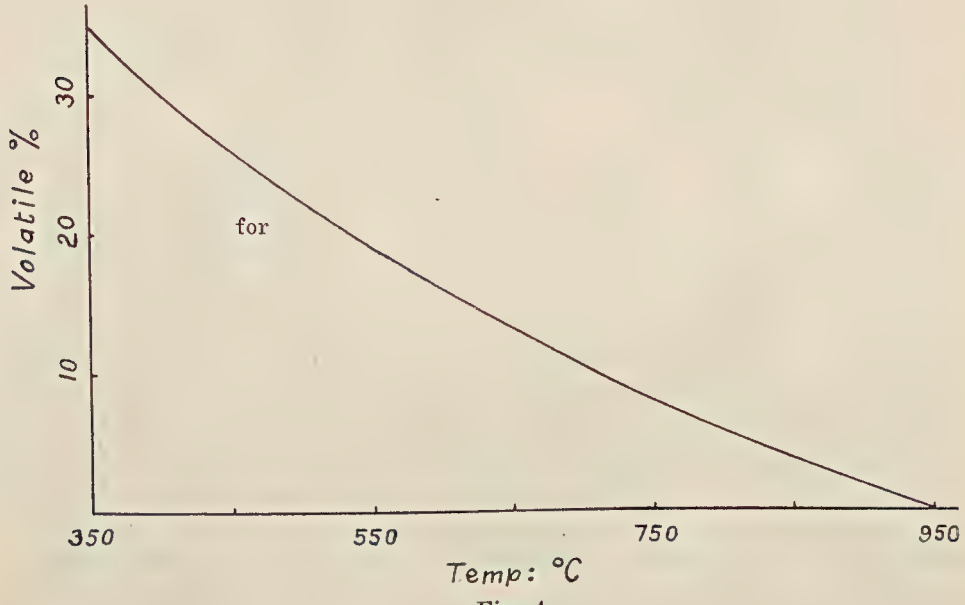

Fig. 4.

(1) To satisfy this condition for final temperatures less than 500° C., it is necessary to carbonize the wood in small pieces, cf. Table I.

this; they are for wood carbonized in various ways, e.g., strips, green wood, large dry wood, and reheated charcoal: with a 3-hour soaking at the final temperature, the figures obtained were 23, 23, 22, 22, 21 per cent, and, with a 12-hour soaking, 24, 23, 23, 23, 22, 20 per cent.

Fig. 4 shows the variation of volatile content with final temperature for *E. linearis* (the final temperature being greater than the maximum temperature attained during carbonization). The curves for *E. obliqua* and *E. regnans* are similar, but fall off rather more rapidly.

7.—Shrinkage

The shrinking of charcoal during and after the carbonization reaction clearly plays an important part in the breaking up of charcoal during heating. While the amount of shrinkage in the carbonization of wood in large pieces may not be quantitatively the same as that in the carbonization of small pieces, the behaviour of the latter should give a good qualitative guide to that in the former. Accordingly, longitudinal shrinkages were measured on pieces 4" long by ½" square, and radial and tangential shrinkages on trapezoidal pieces about ½" thick and 1½" square, with sides following the rays and rings. In all cases the wood has been carbonized slowly to avoid cracking during carbonization (for this see § 8). Values of the shrinkages, expressed as percentages of the dry length of the wood, are given in Table III for various final temperatures; they are to be regarded as typical values only, since there is a good deal of variation between experiments. In all cases the charcoal has been kept for three hours at its final temperature.

Table III

	E. linearis.	*E. regnans.*	*E. obliqua.*	*E. rostrata.*	*Ac. dealbata.*	Sassafras.
350° C. Long.	5	6	4	3	6	6
500° C. Long.	12	13	13	10	13	13
900° C. Long.	19	18	18	15	21	21
350° C. Rad.	12	20	14	7	13	19
500° C. Rad.	19	26	19	11	19	25
900° C. Rad.	25	33	26	20	29	34
350° C. Tang.	16	24	18	12	23	22
500° C. Tang.	23	29	22	17	30	28
900° C. Tang.	30	36	29	21	37	38

It will be seen that the radial and tangential shrinkages are much greater than the longitudinal, and that in all cases there is a considerable shrinkage on subsequent heating after the carbonization reaction is over. Thus, particularly when carbonization is propagated radially, and when external temperatures are fairly high, differential shrinkage may be expected to be the chief mechanism of the breaking up of charcoal into smaller pieces. Shrinkages for all timbers examined are seen to be of the same order, those for *E. rostrata* being lowest.

8.—The Effect of External Conditions on the Nature of the Charcoal

In §§ 2-5 the temperatures attained in a log when carbonizing have been studied and have been found to be considerably influenced both by the size of the log

and the external temperature conditions. For example, it follows from Table I that for *E. linearis* it is possible only with small diameter wood and with a low rate of increase of external temperature to keep the internal temperature of the wood low and to produce a 'quiet' reaction. The nature of the charcoal produced by the experiments of Table I varies very widely; thus the 1·2″ diameter wood yielded a very hard homogeneous charcoal, all in one piece; with the increase in diameter the charcoal commences to break up into small pieces, and also becomes more friable. The breaking up is presumably due to differential shrinkage caused by the increase of internal temperature. The increase of friability appears to be due in part to another cause, namely, the increasing violence of the reaction which causes the gases given off to burst small channels in the carbonizing wood for their escape. These channels appear as small cracks (1) in the charcoal, and cause a great decrease in its strength.

It is reasonable to suppose that it is the rate of increase of temperature near the carbonization temperature that gives rise to a violent reaction. To determine the effect of rate of increase of temperature, experiments were made on strips ½″ square by 4″ long, which could be heated rapidly in a small retort in a muffle. In Table IV for *E. linearis* the rates of increase of retort temperature, the violence of the reaction (as observed qualitatively from the evolution of distillates), and the nature of the charcoal are shown. The actual rates of increase of temperature in the wood will be greater than those shown in Table IV, but for such thin strips the difference will not be large.

TABLE IV

Rate of Temp. Rise ° C./min.	Reaction.	Charcoal.
20	Very fast	Much broken
18	Fast	Less broken
15	Medium	Small cracks only
11	Slow	Practically solid
6	Very slow	Solid

It follows that, for production of best quality charcoal from small pieces of wood, a rate of temperature rise of about 10° C. per minute is critical. A rate of the same order might be expected to be critical in the interior of the timber, and, as a larger rate (20° C. per minute) is recorded in Table II for *E. linearis*, it seems that a certain amount of loss of mechanical strength is to be expected from this cause in timber of any size. The other timbers examined in this way are *E. obliqua*, *E. regnans*, *E. rostrata*, *Acacia dealbata*, and Sassafras. The first two eucalypts show behaviour practically identical with that of *E. linearis*. *E. rostrata* (2), *Acacia dealbata*, and Sassafras will stand a greater rate of increase of temperature without deterioration, and the former also shows a much smaller maximum rate of increase of temperature in Table II.

(1) These are not due to shrinkage of the wood in drying; check experiments of Table IV have been made with oven dried wood.

(2) It may be remarked that the experiments proposed by Miss Plante [*J. Council for Scientific and Industrial Research*, 14, 3 (1941)] in which wood is carbonized in strips 1″ square will, for the reasons discussed above, not be a reliable guide to the mechanical properties of charcoal produced from larger logs, though experiments with *E. rostrata* might indicate that they were.

In cases such as those of § 5 in which the maximum rate of increase of temperature is very high, a very poor quality charcoal is produced.

9.—Practical Conclusions

The most immediate practical application of these results is to carbonization in large retorts. It might be hoped that by a slow carbonization a very solid charcoal might be obtained; however, unless the wood is carbonized in small pieces, the improvement in quality is not very great.

The reason for the poor quality of open-pit charcoal is fairly clear, namely, the high external temperature which gives a violent carbonization reaction. Differential shrinkage will cause the subsequent breaking up of the charcoal.

In the Kurth continuous kiln the conditions seem to be very similar to those in the experiments above: most of the heat is obtained from the reaction itself, and the charcoal has some time to soak at the maximum temperature generated by the reaction. It may thus be expected to attain a temperature of 500° C. and to emerge with a volatile content from fig. 4 of about 22 per cent. Only *E. regnans* has been burnt in this kiln, and the observed volatile contents are about 15 per cent, in good agreement with the equivalent for *E. regnans* of fig. 4.

10.—Green Wood

The behaviour of green, and half dry, wood is entirely different from that previously described, for the following reason: if heating takes place at temperatures of the order of those occurring in charcoal burning practice, the wood checks severely while drying during the early part of the heating and splits up into flakes about $\frac{1}{8}$" thick, running radially inwards, separated by air spaces of much the same size. The sap wood alone remains solid. The flakes of wood carbonize as an assemblage of thin strips, rather than as a single piece, and thus their behaviour resembles that of small pieces of wood. The reaction is thus 'quiet', and the maximum temperature attained less than that for dry wood. For example, a 3" diameter piece of *E. linearis* of moisture content 66 per cent shows, under the conditions of Table II, a maximum temperature of 395° C., a maximum rate of increase of temperature of 7° C. per minute, and a maximum rate of flow of distillate of 1·4. The maximum rate of flow of gas is also much less for green than for dry wood.

We are indebted to the Tasmanian Technical Committee on Fuels, and to the C.S.I.R. grant to the University of Tasmania, for financial assistance.

The Royal Society of Tasmania

1941

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His Majesty the King.

President:

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

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H. Allport, LL.B., 1941, 1942.

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W. H. Clemes, B.A., B.Sc., 1941, 1942, 1943.
L. Cerutty, B.A., Dip.Ed., 1941, 1942, 1943.
W. L. Crowther, D.S.O., M.B., V.D., 1941, 1942.
A. L. Meston, M.A., 1941, 1942.
V. V. Hickman, B.A., D.Sc., 1941.
A. N. Lewis, M.C., LL.D., 1941.

Standing Committee:

W. L. Crowther, E. E. Unwin, V. V. Hickman, J. Pearson.

Hon. Treasurer:

S. Angel.

Hon. Editor:

Joseph Pearson, D.Sc. (Manc.), D.Sc. (Liverpool), F.R.S.E., F.L.S.

Auditor:

H. J. Exley, M.A.

Secretary and Librarian:

Joseph Pearson.

Annual Report

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 11th March, 1941.

The following Office-bearers were elected:—

Under the Society's Rules Mr. W. H. Clemes retired from the office of Vice-President, and Mr. Henry Allport was appointed in his place (retiring 1943).

Treasurer: Mr. S. Angel.

Under the Rules Mr. N. P. Booth and Mr. Henry Allport retired from the Council, and the following members of the Council were elected in their place:—

Mr. W. H. Clemes (retiring 1944).
Mr. L. Cerutty (retiring 1944).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.
Assistant Librarian: Mrs. Clive Lord.
Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens in accordance with the amended Tasmanian Museum and Botanical Gardens Act:— Mr. W. H. Clemes and Mr. E. E. Unwin.

Nine meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

Library

During the year 236 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 278, being made up of 130 British, 55 American, and 93 from other parts of the world. The Library now consists of 20,125 volumes.

The sum of £43 9s. 5d. was spent on books during the year, and the amount allocated as follows:—

	£	s.	d.
General Fund	6	15	4
R. M. Johnston Fund	16	15	11
Morton Allport Memorial Fund	14	18	6
Beattie Memorial Fund	4	19	8

In addition the Tasmanian Museum spent £3 8s. 6d. on books which have been placed in the Society's Library for safekeeping, and are available to members.

Membership

The Society consists of the following members:—

	1940.		1941.
Honorary Members	2	....	2
Corresponding Members	3	....	3
Life Members	7	....	7
Ordinary Members	227	....	210
Associate Members	6	....	5
	245		227

During the year 26 names were removed from the ordinary membership owing to deaths, resignations, &c., and 9 new names were added, including 1 from associate membership.

Also, 2 resignations were received from associate members and 1 member was transferred to ordinary membership, while 2 new members were added.

The Council regrets having to record the following deaths during the year:—Miss M. B. Adams, Mr. A. E. Blackman, Mr. W. F. D. Butler, Mr. H. N. Grant, Mr. J. J. Millen, Mr. R. S. Padman, Dr. A. W. Shugg.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

Safeguard of Valuable Material

During the year the Council considered the question of removing some of the Society's valuable manuscripts, documents, and other irreplaceable material to places of safe keeping. The Council asks for further assistance from members in this connexion.

Abstract of Proceedings

10TH MARCH, 1941

Annual Meeting.

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1941:—Mr. Henry Allport was elected Vice-President in the place of Mr. W. H. Clemes, who retired under Rule 12; Mr. W. H. Clemes and Mr. Leonard Cerutty were elected in the places of Mr. N. P. Booth and Mr. Henry Allport, who retired under Rule 21; Treasurer, Mr. S. Angel.

Mr. H. J. Exley was elected Hon. Auditor in the place of Mr. Walter Taylor, who retired after many years of valuable service to the Society.

Mrs. J. D. Morris was elected a member of the Society.

Mr. M. W. F. Tweedie, of the Raffles Museum, Singapore, gave an illustrated lecture on the Natural History of Malaya.

7TH APRIL, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The Archbishop of Hobart, the Most Rev. Justin Simonds, gave a lecture entitled 'The Psychology of Laughter'.

12TH MAY, 1941

A special meeting was held in the Society's Room on this date. Mr. E. E. Unwin presided in the absence of the President.

The business of the special meeting was to consider the proposal of the Council to amend Rule 67 as follows:—After the words 'Special Meeting' to add 'Notice of any proposed alteration shall be posted in the Library for not less than six days before the meeting'. It was pointed out by the Secretary that in revising the Rules in 1937 an important provision regarding the alteration of Rules had been overlooked. Old Rule 56 required that any proposed alteration to the Rules should be posted in the Library for not less than six days before the special meeting, and it was the wish of the Council that this omission should be made good. It was proposed by Mr. Meston and seconded by Dr. V. V. Hickman that the amendment to Rule 67 as stated above be accepted by the Society. This was carried without dissent.

The special meeting then concluded its business and a general monthly meeting was held.

The following were elected members of the Society:—Ordinary Members, Mr. C. C. McShane, Mr. H. O'May; Associate Members, Mr. W. B. Mather, Mr. A. Wardrop.

The Chairman exhibited a specimen of Lambs Tails *(Trichinium spathulatum)* of the Order *Amarantaceae*. This genus, which is purely Australian, is represented by 16 species in South Australia, but by only one species in Tasmania. It is found in the drier parts of the State.

The Secretary exhibited a collection of coloured copper engravings of Tasmanian scenes made by Joseph Lycett in the early part of the 19th century. Lycett, who was transported to Australia for forgery, arrived in New South Wales in 1810, and during his sojourn in Australia was responsible for a considerable amount of artistic work, including coloured drawings of New South Wales and Tasmania, which were made by him in 1819-21. In 1822 he obtained a free pardon and returned to England, and in 1824 he brought out his 'Views of Australia' in 13 parts. These consisted of 24 drawings of Tasmanian scenes and 24 of New South Wales scenes. The earlier plates were lithographed, but the later ones were engraved on copper. In 1825 the complete set was re-published in London as a single volume consisting of 48 plates, together with a map of Tasmania dated 1825 and a map of New South Wales dated 1825. The earlier plates, which had been lithographed, were re-engraved on copper, so that the complete set of the drawings in the single volume are copper engravings. It was stated that the 24 Tasmanian pictures would be exhibited in the Tasmanian Museum. They were purchased from the funds of the Friends of the Tasmanian Museum and Art Gallery.

Mr. J. W. Nicholls, F.R.C.O., A.R.C.M., then delivered a lecture on 'Some Aspects of Music', of which the following is an abstract:—

> Mr. Nicholls in tracing the trends of music gave pianoforte illustrations of his lecture. Music until about the year 1200 was, he said, little more than rhythm, and was purely melodic. Counterpoint, or a collection of tunes, then developed. The mediaeval centre of learning, the Church, began to develop the art of noting music, and later, with the growth of opera, the modern conception of harmony began, and its rise was helped by the increasing success of instrument makers. Contrasting the music of Bach and Handel, Mr. Nicholls said that Bach's connexion with the Church, and thus the counterpoint type of composition, determined his style. Handel was associated with opera, and wrote in a more modern manner according to the operatic characteristics of the day.
>
> The great characteristic of the classic composers was the creation of beauty, shapeliness, and form, while the composers of the romantic age, such as Chopin, Schumann, and Wagner, wrote to express their own emotions or feelings, engendered by art and literature. The modern trend was towards the discovery of new paths in music, new outlooks, and modern composers aimed through experiment, at being different at all costs.

8TH JUNE, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mr. C. E. Kalmberg, Mr. M. S. R. Sharland.

Dr. J. W. Evans delivered an illustrated lecture entitled 'Recent Progress in Entomology in Tasmania', of which the following is an abstract:—

> The first part of the lecture was devoted to an account of investigations in the field of applied entomology, research concerned with two pests receiving special attention. These were the Light Brown Apple Moth *(Tortrix postvittana)* and Underground Grass Grubs (*Oncopera* spp.). Other insects discussed were Pasture Dung Beetles, the Lucerne Flea, the Cabbage Butterfly, and the Canary Fly and its parasite. The parasite of the Canary Fly is an egg-parasite, which was introduced into Tasmania from New Zealand in 1936. Reference was also made to the control of oak insect pests by parasites, the recent introduction of the Gorse-Seed Weevil, and an investigation that had been undertaken concerned with the food of trout.
>
> In the second part of the lecture the value of systematic entomology was stressed and three interesting Tasmanian insects discussed. These were the primitive sucking-bug

Hemiodoecus fidelis, which is believed to be the only living insect which has retained flaps on the first segment of the thorax that are homologous with wings; the cicada *Tettigarcta tomentosa*, with which both sexes have non-functional sound-producing organs, and the recently discovered Panorpid *Apteropanorpa tasmanica*. The last-mentioned insect is not only the first completely wingless representative of the family to be described, but the first Panorpid to be recorded from Australia. In concluding the lecturer stated that entomological research, as well as being of benefit to the community, was extremely fascinating.

14th July, 1941

A meeting was held in the Society's Room on this date, The President, His Excellency the Governor, presided.

Mr. Ian R. Boss-Walker was elected a member.

Dr. C. R. Brothers gave an illustrated lecture entitled 'Eugenics: The Medical Aspect', of which the following is an abstract:—

He pointed out that it is difficult to prove that mental diseases are on the increase, although recognition and commitability are undoubtedly on the increase. He stated that male psychotics marry less frequently than females, and those who are mentally sick do not tend to reproduce themselves.

He gave lukewarm support to the aims of eugenics, but was of opinion that although it is doubtful if the race can be improved by eugenic methods, it would be foolish not to take all reasonable precautions in view of our ignorance of many aspects of human inheritance. He pointed out the difficulty of carrying out selective breeding in the human race, though he agreed with the principal aim of eugenics, which is to improve the human race by increasing the rate of reproduction in the superior strains and decreasing it in the inferior. He then discussed at length the methods sometimes recommended for the elimination of the unfit, namely segregation of mental defectives, contraception, prohibition of the marriage of mental defectives, sterilization of the unfit. An important section of Dr. Brothers' paper was that which dealt with the genetical significance of certain human mental diseases, and he submitted valuable information of the inheritance of mental diseases which he had gathered in the course of his work at New Norfolk and other places. He pointed out, as eugenicists would be the first to concede, that our present knowledge of human genetics has not the precision which warrants the laying down of hard and fast rules for the breeding of the human species. He also criticized the methods which have been used in the investigation of the inheritance of human diseases, and in conclusion he advocated the establishment of a permanent committee to direct future researches into this question.

His lecture was illustrated by interesting pedigree charts of human mental diseases.

During the discussion on Dr. Brother's paper Dr. Pearson pointed out that biologists welcomed the information on the inheritance of human diseases which is steadily being compiled by a relatively few medical practitioners. Much of the information regarding the family history of disease obtained from patients should, however, be treated with considerable caution. His personal experience of pedigrees of human diseases, which are mostly compiled from the hearsay evidence of untrained observers, made it difficult to reconcile these pedigrees with the known facts of genetics. He recommended the establishment of a central Commonwealth body which would keep records of the medical history of every citizen of the Commonwealth. Such records would ultimately have considerable value in throwing light upon the inheritance of human diseases.

The lecture on 'The Biological Aspect' by Dr. Pearson was not given owing to insufficient time.

11th August, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

Mr. James Glennie was elected a member.

Mr. M. S. R. Sharland delivered an illustrated lecture on 'The Life of the Lyre Bird' of which the following is an abstract:—

Mr. Sharland said that, although lyrebirds had been introduced into Tasmania with the stated object of preserving them from the fox, which did not occur in this State, he did not think there was any danger of the bird ever becoming extinct in the regions to which it was indigenous, namely, the coastal parts of Victoria and New South Wales and the southern part of Queensland. This was because a popular sentiment had grown up about the bird, and was responsible for its greater protection. Publicity had brought the bird into public prominence, and it is now recognised by Australians as unique, and efforts were being made to conserve it. Nevertheless, Tasmania was glad to receive birds, and he thought they would thrive in National Park, where they had been liberated.

The lyrebird generally placed its nest on the ground, and normally laid only one egg, the incubation period of which was about six weeks. The young bird then remained in the nest for another six weeks. This meant, for nearly three months, the egg and young were exposed to attacks by ground animals, and a pair of birds was fortunate if they reared their young one successfully. This factor operated to the detriment of the bird's survival and increase.

The lyrebird preferred dense forest and nested during the winter months. It was especially notable for its mimicry and its ornamental tail.

8TH SEPTEMBER, 1941

A meeting was held in the Society's Room. Mr. E. E. Unwin presided in the absence of the President.

Dr. L. A. Triebel delivered an illustrated lecture entitled 'Pasteur—A Play in Five Acts, by Sacha Guitry', of which the following is an abstract:—

At the beginning of this century the traditions of the French bourgeois drama coming from Emile Augier and the younger Dumas blended with the newer Ibsen-inspired realism of the Théâtre Libre, favouring social problem-plays like those of Brieux. The 'slice of life' obsession had reactions. Edmond Rostand revived the romantic, rhetorical drama with his eccentric but generous Cyrano de Bergerac, and the patriotic Chantecler. Maurice Maeterlinck and Paul Claudel started on a poetic, mystical and symbolist programme of lofty aim; whilst a legion of young playwrights, among them Courteline and Sacha Guitry, wrote French comedy with a new-old gusto and mastery. As playwright, theatrical manager and actor, Sacha Guitry, son of the famous actor Lucien, produced many entertaining comedies followed by a series of pageant-plays that were dramatized biographies (Debureau, Pasteur, La Fontaine, Mozart, and Béranger) most of them enlivened by the voice of his wife, Yvonne Printemps.

'Pasteur' was performed for the first time in the Théâtre du Vaudeville on the 23rd of January, 1919, and printed by Fasquelle of Paris. It was dedicated to Lucien Guitry, and the preface states that the idea of dramatizing the life of the scientist came to Sacha Guitry three years after reading the biography by M. René Vallery-Radot of his father-in-law, Louis Pasteur. In spite of difficulties this intention was fulfilled when Lucien Guitry invited Sacha to write a play especially for him. Vallery-Radot was re-read with great enthusiasm, 'For', said the younger Guitry, 'it seemed to me that I had the right to undertake a piece of work to which I felt irresistibly drawn. I have several times taken the liberty of using whole sentences as spoken by Louis Pasteur at meetings of the Academy of Medicine and elsewhere'.

Here appear both the initial impulse and the aim of Guitry: the inspiration of a great biography and the intention to honour a national scientist. The verbal indebtedness of the playwright goes beyond the italicised quotations, although in some instances he condenses, as in the Joseph Meister case (Pasteur, pp. 80-82, corresponding to Vallery-Radot, pp. 600-605). Act 2 brings the members in debate, and is based on the proceedings of the Academy. The impersonal form of the biography is here expanded and broken up into dramatic dialogue: some rôles are invented.

'Pasteur' is a series of dramatic portraits showing the scientist at five different moments of his life between the ages of 48 and 70. This breaks with the French dramatic tradition: Boileau had condemned characters ageing during the action. Moreover, there was the Aristotelian demand that the dramatic hero must not be flawless. Guitry succeeded dramaturgically by concentrating on the clash of wills between Pasteur and his opponents brought about by anger and irony in debate.

The multiplicity of dramatic characters dominated by one master figure is a conception found in Marlowe and others; but 'Pasteur', like Drinkwater's slightly earlier 'Abraham Lincoln' (1918), is essentially pageant, a series of tableaux-scenes. Australian literature has the similar 'Spinoza' (1932) by Professor Alexander Gunn. In these plays the historic events are mere agencies: 'the bearing of man facing it, is all'. Yet Guitry's task was more difficult than Drinkwater's: bacteriologists do not as yet loom as large as statesmen and generals. The pros and cons of spontaneous generation, of fermentations, microscopic control, and the infectivity of contagious diseases may be comparatively poor grist for the dramatic mill. There was a Lincoln legend; was there a Pasteur legend?

Guitry's selection of incidents from Pasteur's life was conditioned by their relation to national life: bacteriologist and patriot merged in him. The play begins effectively in 1870 with Pasteur's resolve to regain for France a leadership in scientific humanism and to turn on her the eyes of mankind for help and healing. Before the Medical Congress of all Nations at Copenhagen in 1884 he said, 'In every great scientist will be found a great patriot. The thought of adding to the greatness of his country sustains him in his long efforts, and throws him into those difficult but glorious scientific enterprises which bring about real and durable conquests'. (Vallery-Radot, p. 570.) The play ends with the presentation in the Sorbonne by the President of France of a commemorative medal on Pasteur's 70th birthday, the occasion of worldwide tributes. The final words are his 'I believe absolutely in the triumph of science and peace over ignorance and war'.

Guitry's interpretation is just to Pasteur, man and patriot, as was Lucien Guitry's acting of the rôle. Drama like this is the expression of the spirit of free inquiry, the University spirit, struggling long but victoriously against embattled forces alongside of which neither science nor literature can live. The Guitrys re-incarnated Pasteur, the soul of France, and without her the world would be alone.

The Drinkwater triumph in 'Abraham Lincoln' was the final impulse urging father and son similarly to dramatize France's greatest scientist:—

'This is the wonder always, everywhere—
Not that vast mutability which is event,
The pits and pinacles of change,
But man's desire and valiance that range
All circumstance, and come to port unspent'.

13TH OCTOBER, 1941

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Mr. W. H. Hudspeth read a paper by Miss A. L. Wayn, Government Archivist, entitled 'Sir George Arthur, Lieut.-Governor of Van Diemen's Land, 1824-1836', and maps and drawings connected with Governor Arthur were exhibited. The following is an abstract of the paper:—

George Arthur was born in 1784, the youngest son of John Arthur of 'Norley House', Plymouth. He entered the Army in 1804 as ensign in 91st Argylshire Highlanders, was gazetted lieutenant in 1805, captain in 1808, and major in 1812. He served in Egypt, Italy, and Flanders during those years, and was wounded severely on two occasions. For distinguished gallantry at an attack on Flushing, he was thanked in General Orders and appointed Deputy Assistant Adjutant-General on the field. On his return to England he received the freedom of the City of London and was presented with a sword. Plymouth accorded him similar honours.

In 1812 George Arthur was gazetted to 7th West India Regiment stationed in Jamaica, and, on arrival there, was appointed Assistant Q.M.G. to the forces in that Colony. In 1814 he married Eliza Orde Usher-Smith, second daughter of Lt.-General Sir John Frederick Sigismond Smith, K.C.B. Seven children were born of their marriage; three of the sons joined the Army; a daughter became the wife of Sir Bartle Frere.

In 1814 George Arthur was appointed Superintendent and Commandant of British Honduras, with the local rank of Colonel, holding civil and military command, a position which he held for eight years. He received the full rank of Lt.-Colonel in 1815, and was placed on half pay in 1819. During his term of office in Honduras, a revolt of the slave

population broke out in consequence of their brutal treatment by plantation owners. This had to be suppressed for the sake of law and order, but the cruelties practised on them by their owners made Arthur an ardent abolitionist. His protests through the Colonial Office gave a strong filip to the cause among those men lead by Wilberforce, who were pleading for the abolition of slavery, though among others he earned contempt as a humanitarian. Arthur had occasion to reprimand the colonel commanding the garrison at Honduras for undue use of the lash as a punishment. Bradley disputed his authority, and was sent to England under arrest. He appealed to the War Office, and was upheld on technical grounds. On Arthur's return home at the close of his term at Honduras, Bradley brought a case of unlawful arrest against him and won his suit, the defendant being fined £100.

At the close of the case Col. Arthur was appointed Lt.-Governor of Van Diemen's Land. That Colony was then suffering under many disabilities, caused by its rapid expansion, the emigration of large numbers of free settlers, its dependence on New South Wales, and its need of a Supreme Court. Social and commercial problems had become acute. The British Government's policy of limiting the number of female prisoners transported was unfortunate from a moral standpoint. Male prisoners had ceased to dread the sentence of transportation; comfortable housing, regular meals, and not inordinately long working hours were an improvement on the life in London's slums, from which a large number were drawn. Their working hours, 7 a.m. to 3 p.m. in summer and 8 a.m. to 4 p.m. in the winter, were not more than the Lt.-Governor's, who was frequently in his office at 7 a.m., and, when not engaged on duties outside it, attended there for the better part of the day, receiving and and answering requests from citizens and settlers.

Though a strict administrator, Arthur ruled his own life and that of his household equally rigidly. It was his reputation as a stern moralist, primarily, which secured his appointment. His humanity brought him more than one reprimand, through the Colonial Office, for his petitions in favour of convicts who had shown marked good conduct, or had acted in the interests of employers when opportunity offered, thus earning in the Governor's opinion some remission on their sentence. In the case of men who had been awarded a ticket of leave and were entitled to claim a wage, he encouraged them to ask for a free passage to the Colony for their families, by which means he hoped to ameliorate the lot of the prisoners and improve the moral life of the island, at least among that class. Governor Arthur decided that life at the penal settlement of Macquarie Harbour was too severe. He opened one at Maria Island in 1825, a place of lighter punishments, and limited the sentence to Macquarie Harbour to three years. However, the Home Government complained of the additional expenditure incurred. This caused his decision to close both and take over the sawmilling station near Stewart's Harbour as an ultra-penal settlement in 1833. Employment at Macquarie Harbour had been chiefly timber-milling and ship-building. These were continued at the new settlement (to be known as Port Arthur), with the addition of coal mining, which developed further under succeeding Governors. The change to more genial surroundings was shown in the marked improvement in the conduct of the prisoners. Numbers were brought back after short intervals to the settled districts for lighter service.

Under his commission of Lt.-Governor, Arthur was directed to protect the native population. His natural kindness of heart made him anxious to further their interest in any case, but the position was difficult. Constant complaints were sent in by settlers of the theft of their sheep and cattle and the death of their stockmen from frequent native raids. Revenge taken by the owners led to more hostilities, until the Governor was forced, in 1828, to proclaim martial law. On its failure, the 'Black Line' was carried out a year later in the hope that many natives would be captured and segregation of their race could be carried out systematically. The Line, which was formed by a chain of temporary small camps across the Colony, manned by Military and settlers, proved a dire failure and a heavy expense to the Home Government. Eventually the offer of a builder named George A. Robinson was accepted to attempt the capture of small parties. He had previously won the friendship of those whom curiosity and the encouragement of the Governor and residents had brought into Hobart Town from time to time, and was hopeful of success. Accompanied by two or three natives, he was able to persuade others to come in with him in the next few years. In 1832 segregation was begun at Flinders Island and Robinson was appointed Superintendent of the Settlement, with a catechist, a doctor, and a small party of Military. Though it proved a failure in later years, it is recorded that the arrangements laid down by Col. Arthur showed excellent judgment and sympathy with their needs.

Bushranging was rife in the Colony before and after his administration began. His measures improved matters for short periods, but a large military force was necessitated to keep down their increase in the Colony for many years.

Van Diemen's Land received a separate constitution and independence from New South Wales in December of 1825. Governor Arthur laid down the civil departments and published

a clear statement of the work to be carried out by each. He enlarged the personnel of the Executive and Legislative Councils, inaugurated the Bench of Magistrates, appointed a Colonial Secretary (formerly known as governor's secretary), a Treasurer, and Auditor, and instituted Trial by Jury. A Supreme Court had been established in 1824, the year of his appointment. Prior to 1827 an official known as 'Naval Officer' collected the entire revenues. After the appointment of a Treasurer, his duty was confined to harbour and post collections. In 1829 His Majesty's Customs Department established a branch in the Colony.

The need of churches and schools in Van Diemen's Land was serious in the 'twenties'. The Home Government consented to the erection of six of the former and the establishment of district schools in settled districts, under masters, some of whom were catechists also, and four or five chaplains were sent out to serve the churches built and under erection.

The Survey Department was insufficiently staffed to cope with the amount of field work entailed by the increasing number of free grants to incoming settlers during those years. Boundaries were not clearly pegged out, and in many instances grantees built and cultivated lands inside their neighbours' acreage. Restitution and readjustment entailed expense to the Government. The Governor was blamed by the settlers, though the trouble began before his arrival; while the Home Government resented the expenditure.

Colonel Arthur received his recall after 12 years of administration. He carried with him from Van Diemen's Land numerous Addresses expressing appreciation of his reforms and of the Colony's marvellous advance in prosperity during his term of office.

On arrival in England Colonel Arthur received the honour of knighthood, and was appointed Governor of Upper Canada. Trouble occurred in 1838 between the two provinces, and rebellion broke out. The British Government decided to merge Upper and Lower into one province. Sir George disagreed with that policy, and asked to be allowed to return to England. His resignation was accepted. The Canadian Press eulogized his statesmanship and manly qualities.

After his arrival in England the Queen forwarded him her gracious approbation of his services, and created him a Baronet. In 1842, a year after his return, he was appointed Governor of Bombay.

During his service in India, the Press of that country invariably praised his administrative qualities. Its testimony was endorsed by Sir Henry Hardinge, the Governor-General, when on the threat of an outbreak of war he advised the British Government, in the event of his having to take to the field, to appoint Sir George Arthur to his own office. The Government agreed to his suggestion, but the proposed honour came at a time when the administration of his province was almost beyond Arthur's physical strength. The long years of strain had taken their toll, his health grew worse in 1846, and he asked to be allowed to resign. The change back to his native climate brought improvement.

In the following year he was made a member of the Privy Council, and received the Honorary Degree of D.C.L. of Oxford. In 1853 Sir George was gazetted Colonel of the 50th Regiment, and in 1854 was promoted Lieut.-General. During that year he was attacked by a severe illness. His death occurred on 19th September at his home in Gloucester Square, Hyde Park, London, in his 71st year.

Though Sir George received the approbation of his Sovereign and was eulogized by the current press of the other countries in which he held office, modern writers have continued to allow the malignity expressed by the ex-convict editors of Van Diemen's Land to mar the name and memory of a man who has since been entitled 'One of the British Government's greatest Pro-consuls'.

The following papers were laid on the table and taken as read:—

(1) A Tasmanian Stone Implement made from bottle glass. By N. B. Tindale.

(2) Some Tasmanian Palaeozoic Corals. By Dorothy Hill.

(3) The Grapsid and Ocypodid Crabs of Tasmania. By M. W. F. Tweedie.

(4) New Leaf-Hoppers from Tasmania and Queensland. By J. W. Evans.

(5) A Mecopterous Larva from Tasmania, and Notes on the Morphology of the Insect Head. By J. W. Evans.

(6) The Nitrogen Bases in Tasmanite Shale Oil. By R. F. Cane.

10TH NOVEMBER, 1941

A meeting was held in the Society's Room on this date. Mr. Henry Allport presided in the absence of the President.

Mr. H. G. Vaughan was elected a member.

The following papers were laid on the table and taken as read:—

(1) A New Ichthyobdellid Leech and Its Egg-Capsules. By V. V. Hickman.
(2) Observations on Some Tasmanian Fishes: Part V. By E. O. G. Scott.
(3) The Phylogeny of the Homoptera. By J. W. Evans.

Mr. L. R. S. Benjamin delivered an illustrated lecture entitled 'Some Aspects of the Development of the Eucalyptus Pulping Industry and the Manufacture of Newsprint', of which the following is an abstract:—

The lecturer pointed out that conifers have been the source of supply of wood pulp for the paper industry for nearly three generations. The feasibility of using eucalypts for the manufacture of newsprint was considered very doubtful twenty-five years ago, and it is since that time that a process has been evolved by which the Tasmanian hardwoods can be utilized successfully in the manufacture of paper pulp.

Mr. Benjamin first explained at some length the structure of natural wood, and pointed out that the fibres constitute the 'units' of pulp. Conifers are more easily adapted for the making of pulp than eucalypts, as the fibres of the former are very much longer than those of the latter, and it was for this reason that H. E. Surface in 1916 stated that eucalypts were entirely unsuitable for making pulp. The weight of opinion at that time was strongly against the feasibility of using short-fibred wood pulp from eucalypts for any purpose other than as a filler to produce bulk and opacity in certain types of paper. The first aim of the paper manufacturer is to reduce the wood to its constituent fibres. The structural elements of wood are essentially cellulose, which is insoluble and not readily digestible. The separation of the cellulose fibres can be done by chemical as well as mechanical means. The essential principle of paper-making is the suspension of these macerated fibres in water and then straining them on a sieve. If the sieve takes the form of an endless belt a continual sheet of paper is produced.

The lecturer then described the various processes by which wood is converted into pulp, including the mechanical or grinding process and the chemical process, and he pointed out that at Boyer the grinding process is used. The pulp then undergoes a treatment known as beating. This is a mechanical process which develops the colloidal properties of the cellulose fibres. Different types of papers can be produced by a longer or shorter beating. In the case of newsprint, beating does not play an important part, as the principal ingredient is ground wood pulp, which no amount of beating will improve.

Mr. Benjamin then outlined the progress and sequence of experiments which have been made in the last twenty-five years in order to find some method of utilizing eucalypts in the paper-making industry. In their early experiments it was found that the percentage of cellulose was quite as high as in the soft woods and that pulp of high strength could be made from eucalypts by the proper combination of cooking factors. When the process had been established and success was assured, the Derwent Valley was recommended as the seat of the newsprint industry because here alone sufficient quantities of *Eucalyptus regnans* exist to supply the needs of an industry which must operate at least 400 tons of paper daily. Eucalyptus newsprint, therefore, may be regarded as a symbol of what can be achieved by the application of scientific methods to industrial problems.

Northern Branch

Annual Report, 1941

Meetings of the 1941 Session, other than the Annual Meeting and Public Lecture and the September Meeting, were held in the Lecture Room at the Queen Victoria Museum and Art Gallery.

26TH MAY, 1941

Annual Report and Public Lecture

The Annual Meeting for 1941 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1941:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields, Mr. W. R. Rolph, Mr. G. McKinlay, Mr. J. R. Forward, Mr. D. V. Allen, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon. Auditor: Mr. J. R. Forward.

The Annual Report and the Statement of Accounts, which showed a credit balance of £35 17s. 3d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Frenchman's Cap' by the Branch President, Mr. F. Smithies. The lecture was given in the Public Library Hall; there was an attendance of upwards of two hundred and fifty.

Mr. Smithies traced the history of the Frenchman's Cap (origin of name unknown; possibly bestowed by one of the French explorers in passing along the coast in 1870), with reference to Surveyor W. S. Sharland, 1832 (Sharland, extracts from whose diary were read, confused the Derwent, and thought that Lake St. Clair, which he saw from Mount Charles, and named Gordon Lake, was the source of the Gordon River); James Sprent, about 1850 (reached the summit, and erected a trigonometrical cairn); Tulley, Glover, and Spon, 10th January, 1857; T. B. Moore, 1888 (first ascent from western side); F. E. Philp, 1910 (made track to mountain, but did not climb it); track cut from Crotty in 1913 used by several parties from Queenstown under the guidance of the late Charles Whitham (this track remained open for only three years and was disused after 1916); F. Smithies and C. Bradshaw, 1932; A. I. Davern, 1933.

The second section of Mr. Smithies' lecture took the form of the projection of a number of lantern slides and of a moving picture in full natural colour showing various stages of a recent ascent of the mountain by himself, Mr. R. Hall, and Mr. P. H. Bond.

23RD JUNE, 1941

The President, Mr. F. Smithies, presided.

Mr. R. Boswell gave an illustrated lecture on 'Modern Museum Display Methods'.

Mr. Boswell's address fell into three sections—first, a general account of the speaker's recent visit to U.S.A., under the auspices of the Carnegie Corporation of New York, to attend a course of instruction in taxidermy and museum preparation, conducted by Mr. Frank Tose, Chief of Exhibits, California Academy of Sciences, San Francisco; secondly, a survey of some modern techniques (with special reference to latex preparations); thirdly, an account of the various stages in the mounting of a mammal.

In dealing with some modern developments in museum preparation, the speaker supplied some very interesting information on methods of moulding and casting in latex, a very adaptable, and now widely used, medium: Latex preparations of reptiles and amphibians

were handed around for inspection. Mr. Boswell then traced in detail the various steps in the mounting of a gnu, the successive stages involved being illustrated by photographs projected by an epidiascope.

The lecture was followed by a discussion, to which nearly all the members present contributed.

28TH JULY, 1941

The President, Mr. F. Smithies, presided.

Mr. J. B. Boag gave a lecture on 'Textile Dyeing'.

Mr. Boag, Research Chemist, Paton's and Baldwin's Mills, introduced his subject by a brief historical survey of dyeing from the early times, and laid down a fundamental distinction between household dyeing and dyeing by processes on a commercial scale. He then proceeded to make a systematic survey of six main groups of dyes, of the methods of using them, and of their reactions on vegetable and animal fibres. The principles of mordanting were discussed; and interesting references were made to practical problems encountered in commercial dyeing.

Mr. Boag then proceeded to trace in detail the whole process of dyeing a fabric, such as a suiting. Fairly full consideration was given to various aspects of colour-matching, fastness of dyes to light and water, and production of non-shrink fabrics, the successful approaches of modern research to these problems being demonstrated by the display of an extensive series of samples.

The lecture was followed by a discussion, in which virtually all members present participated.

25TH AUGUST, 1941

The President, Mr. F. Smithies, presided.

Mr. M. S. R. Sharland gave a lecture on 'The Life of the Lyre Bird'.

29TH SEPTEMBER, 1941

The President, Mr. F. Smithies, presided.

The September meeting was held in the Main Hall, Public Library.

The Hon. the Minister for Lands and Works, Hon. T. H. Davies, presided.

Mr. F. W. Hicks, Superintendent of Agriculture introduced Mr. C. L. Goldstone, B.Sc.Ag., who gave a lecture on 'The Menace of Soil Erosion'.

Mr. Goldstone, who has been engaged for some time in making a survey of the problem of soil erosion in Tasmania, gave a general address on soil erosion, followed by an account of the results of some of his own investigations. In dealing with local examples, the lecturer first discussed the plight of many orchards in the West Tamar district and in southern Tasmania: pictures taken in these localities showed trees with exposed roots, the result of wind or water action. It was pointed out that the honeycombing of land by rabbits frequently gives rise to a state of conditions conducive to extensive erosion by winds. A striking example of water erosion cited is one in which, in one property investigated by Mr. Goldstone, a great gully, by formation of which 15,000 cubic yards of soil had been lost, has been produced by water deepening a plough-line made to drain a paddock. The destruction of land in coastal areas by encroaching sand was also described, typical examples being illustrated by means of lantern slides.

At the conclusion of Mr. Goldstone's lecture, a sound-film, 'The Menace of Erosion' was shown: the film, prepared by the Rural Bank of New South Wales, was screened by courtesy of the Bank.

27th November, 1941

The President, Mr. F. Smithies, presided.

Mr. E. O. G. Scott gave a lecture on 'A Naturalist in Tasmania'.

> After some introductory observations on the scope and complexity of present-day biological research, Mr. Scott pointed out the exceptionally favourable opportunities that exist in Tasmania for work both by the specialist and the field naturalist. General consideration was then given to the geographical and biological characteristics of Tasmania in relation to those of the mainland of Australia, New Zealand, and South America. The striking similarity of the fauna of the regions delimited by Bass Strait was discussed, and it was pointed out that, in many respects, the fauna of the northern half of the State is more closely assimilated to that of Victoria than to that of the southern part of the Island.
>
> The geological history of the State was traced in broad outline to present a general picture of the involved course of events from pre-Cambrian times onward; and some fossils characteristic of the various periods were considered. Some general remarks were made on the interest to the naturalist of our local mammals; and, in conclusion, a brief account was given of some of Tasmania's so-called living fossils.

The lecture was followed by a discussion, in which most of the members participated.

Council Meetings

Council Meetings were held on the 5th May, 9th June, 3rd July, 11th August, 8th September, 14th October, and 1st December.

NATIONAL MUSEUM

H. H. Pimblett, Government Printer, Tasmania.

PAPERS AND PROCEEDINGS

OF

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FOR THE YEAR

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Pap. & Proc. Roy. Soc. Tasmania, 1942 (16th August, 1943.)

The Phreatoicoidea

By

G. E. Nicholls

Professor of Biology, University of Western Australia

(Read 24th August, 1942)

PART I.—The AMPHISOPIDAE

PREFACE

The accumulation of material for a survey of this sub-order was begun as far back as 1925 and a short first instalment was published in the following year. A few months later, however, there appeared a 'Revision of the Phreatoicidae' by Miss Sheppard, but with many of the opinions expressed in that work, and particularly with the systematic grouping proposed, the present writer found himself in marked disagreement.

It was realized, however, that the subject could be dealt with adequately only by a re-examination of a large number of examples of all known species. During the fifteen years which have elapsed since Miss Sheppard's paper appeared, some thousands of specimens have been examined.

Among these were numerous examples kindly loaned by the Directors of the Australian Museum, Sydney, and of the National Museum, Melbourne, as well as the entire collection of Phreatoicids from the Museums at Adelaide and Hobart. This last collection includes specimens obtained in connexion with the Tasmanian Biological Survey and is enormously swollen by the material secured by Mr. J. W. Evans in connexion with his valuable 'Fish Food Investigations'. A debt of gratitude is owing to Professor Wadham of the University of Melbourne, who made several special trips to the Otways Mts. in search of living *Phreatoicopsis*, while Dr. K. Barnard of the South African Museum, Capetown, made a generous contribution of specimens from that region. The late Professor Chilton kindly sent examples of known New Zealand species, while co-types of Geoffrey Smith's Tasmanian forms were given by Professor Bourne. Still more material has been brought together by personal collection in Victoria, Tasmania, New Zealand, and Western Australia, some of these collecting trips being made possible by generous grants from the Trustees of the Australian Science and Industry Endowment Fund, to whom grateful acknowledgment is due.

Thus, the completed paper has grown to such proportions that it has now been found necessary to divide it into two parts for publication. The present part (Part I) deals with the Amphisopidae; Part II, which it is proposed to publish in the 1943 volume of this Journal, will deal with the Phreatoicidae. It is

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unavoidable that certain new genera and species, which will be fully described in Part II, are referred to by name in the present part. Such new names will, of course, have no validity until their full description has been published. It should be added that the cost of printing the paper is being met in part by contributions from the funds of the Tasmanian Biological Survey and of the University of Western Australia, to the authorities of both of which bodies my thanks are tendered. Finally, I am indebted to Dr. Pearson for helpful advice and suggestions concerning the form the paper should take.

INTRODUCTION

Since the appearance in 1894 of the first detailed description of a Phreatoicid (*Phreatoicus australis*, Chilton), many additional members of this group have been described, the authors having, in most cases, been content with a description of the new form in terms of comparison with *australis*. This fashion of description has the sole recommendation that it makes for brevity, but, unless it be accompanied by detailed figures, can be most misleading. For, unlike the Amphipods of which Stebbing remarked (1888, p. 475), that while from their descriptions they might seem to be practically identical, yet when placed 'side by side, it is rather the differences of the facies than the likeness which attracts attention', of the Phreatoicids the reverse is the case. The general external likeness throughout the whole group (excepting subterranean forms) is very marked indeed, and it is only a close scrutiny that reveals the range of structural difference.

Phrases such as 'in general very like *P. australis*', 'like *P. australis* except . . .' and 'as in *P. australis*' constantly recur, being used frequently without sufficient justification.[1] As a consequence, it has come about that a sentence in Chilton's original account of *P. latipes* 'does not differ very much from *P. australis*' can become transmuted in the work of another author (Sheppard) into 'very similar to those of *australis*', although, in fact, the two types present the most markedly dissimilar facies and are, indeed, to be ranked in different families.

It has happened, therefore, in some cases, that such brevity of description has resulted in a mispresentation of the new species, having tended to minimize the significance of characters actually quite distinctive, and often of considerable taxonomic importance. To the reader, there is conveyed the impression that, while there undoubtedy exist, in the form under discussion, differences from *australis*, these modifications are, nevertheless, trivial, and, at most, of specific importance.

Moreover, reliance upon this inexact method of description (failing, as it so often has done, to provide the facts required later for critical comparison) has also been responsible, in some cases, for the lack of sufficiently careful and complete investigation. It has served, too, to foster the quite erroneous idea that *P. australis* is the most generalized of the extant forms and, indeed, closely like the Triassic Phreatoicid from which extant forms might presumably have been derived. This misconception explains the failure to appreciate the existence of two well-marked groups within the sub-order.

The matter is one of considerable importance, for upon its correct understanding depends our recognition not only of the position of the Phreatoicoidea within the Isopoda but also of their relationship to other Peracaridan orders, including the Amphipoda. Barnard (1927), in a valuable contribution to this

[1] The writer admits that he, too, has relied more than once upon this loose and frequently inaccurate method of description.

subject, discusses the evolutionary tendencies within this group, but, influenced by his belief in the 'likeness' of *P. capensis* to *P. australis*,[1] accepts as an established fact the primitive character of the *australis* facies. He endorses Chilton's view of the 'very close relationship to the Asellidae' and agrees that 'the resemblances to the Amphipoda, though interesting, have been exaggerated' (1927, p. 213).

For the alternative view that *P. australis* and its group of nearly related species, mostly sub-alpine, may be modified and stunted forms derived from an older (Amphisopine) type of more robust lowland species, a clear case can be made out.

This suggestion was first made by the writer in 1926, in a paper of which only a summary was published (1928). Since then, all but one of the known species and many others, new, have been examined and have provided evidence supporting the view that the Amphisopine type is phyletically the older. From this viewpoint the closest relationship within the Isopoda would appear to be with the Cirolanidae rather than with the Asellota. To non-Isopodan groups, the Amphisopidae seem nearest akin to the Apseudidae, and since these latter are presumably representative of a more primitive stock of Peracarida, with possible relationship to Amphipoda, the resemblances of the Phreatoicids to the Amphipodan type may be indicative of parallelism in evolution in forms derived from a common stock rather than, as Chilton has maintained, merely a superficial resemblance due to convergent evolution.

The sub-order appears to be an extremely ancient one which, quite early in the Mesozoic, had probably established a fairly stable 'Amphisopine facies'. Further, the divergence of the extant forms from this common stock almost certainly began very long ago, so that many of the existing species, superficially so alike, actually represent widely-separated end branches and should rank as monotypic genera. Several have taken, independently, to subterranean life and there has resulted a new, convergent resemblance in forms that were probably comparatively widely separated phyletically. Thus the attempt to establish an orderly classification of the genera of this sub-order proves a very perplexing business. A number of significant characters have come to light, which can only be interpreted as instances of the retention of more primitive Peracaridan features, and, therefore, their absence or modification attributable to complete or partial suppression. In the extant members of this group, such diverse combinations of presence and absence of these distinctive characters are met with that it becomes a real problem to decide which species is to be regarded as, on the whole, the most primitive, and to attempt to align the remaining forms in correct relation to this and to each other.

The length of this account of the Phreatoicoidea has made it necessary to publish in two parts. Accordingly, it has seemed desirable to include in Part I the list of literature to which reference is made and which would normally come at the end of the paper. It is most conveniently inserted here.

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[1] It may be noted that Barnard's comparison of *capensis* with *australis* (1927, pp. 158, *et. seq.*) is based on examination of specimens from Tasmania (Mt. Wellington) which are not actually *australis*, although undoubtedly nearly related to that species.

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EXPLANATION OF LETTERS, ETC., USED ON FIGURES[1]

1. Entire animal.
2. Head, enlarged.
3. Tailpiece.
4. Antennule and Antenna.
5. Labrum (with Epistome).
6. Mandible.
7. Labium.
8. Maxillula.
9. Maxilla.
10. Maxilliped.
11. Gnathopod.
12. Peraeopod (2)-(7).
13. Pleopod (1)-(5).
14. Penial stylet.
15. Uropod.

a. anterior view; *ac.* acetabular process; *a.m.* antero-mesial view; *ap.* apodeme; *a.s.* anterior row of setae; *b.* basis; *c.* coxa, coxal lobe; *d.* dorsal view; *e.* external view; *en.* endopodite (palp); *ep.* epistome; *ex.* exopodite; *f.* fulcral process; *fil.* row of filtratory setae; *h.* hand; *hl.* hinge line; *l.* left; l^1, l^3, endites of first and third segment of maxilla; *la.* labrum; *m.* mesial view; *ma.* opening for adductor muscle; *md.* mandible; *mo.* molar; *mp.* median process; *ms.* mesial surface of maxilla; *o.* oostegite; *p.* posterior; *pa.* paragnaths; *pct.* pectinate setae; *pl. (1)-(6).* pleura of pleon segments; *pm.* petasma?; *p.mr.* margin, enlarged, of basis of peraeopod; *pp.* palp; *pr.* posterior row of setae; *pr.v.* peraeon in ventral view; *p.t.* pleo-telsonic suture; *r.* right; *s.* lateral; *sp.* spine row; *st.* sternum; *t.s.p.* transverse section through peraeon segment; *t.s.pl.* transverse section through pleon segment; *v.* ventral.

[1] Lines are placed alongside some of the drawings, particularly of drawings of the entire animal. These lines represent a length of 1 mm.

A BASIS FOR CLASSIFICATION.

In order to avoid much repetition, it is proposed to discuss, at this stage, some of the more important characters of diagnostic value; they are:—*(a)* those which relate to the head—the rostrum, eyes, antennule, antenna, mouth parts and cervical groove; *(b)* in the peraeon—the presence of ridges on the segments, the relation of the first peraeon (i.e., second thoracic) segment to the head, that of the coxae of the peraeopods to their segments, the expansion of the bases and other joints in the peraeopoda, the arrangement and number of the oostegites and the occurrence of median sternal processes; *(c)* in the pleon—the characters of pleopods, uropods, and tailpiece; and *(d)* the condition of the typhlosole.

1. Rostrum

In the Peracarida, a rostrum is fairly generally developed. It has, however, largely vanished in the Isopoda (although still present in some Asellote forms). It is of interest, therefore, that in a few Phreatoicoidea there is found, clearly defined and separating the antennules upon the anterior surface of the head, a ridge elongated vertically which suggests a vestigial condition of this structure.

2. Eyes

On the balance of evidence, it seems probably that the ancestral form had eyes, large and well-developed, which have undergone reduction independently and at different times, in members of genera of both divisions of this sub-order, as these abandoned active life in surface waters for a creeping cryptozoic or subterranean mode of life. In the Amphisopidae, the eyes are typically very prominent and large, with many ocelli; they may be smaller but still well developed and prominent *(Mesamphisopus, Uramphisopus)*, or they may have come near to disappearance or be wholly absent *(Hyperoedesipus, Hypsimetopus,* and *Phreatoicoides)*. In the Phreatoicidae, well-developed prominent eyes persist but rarely *(Mesacanthotelson)* and, in most, the eyes are undergoing reduction, are variably small or wanting *(Metaphreatoicus)*, or have gone without trace *(Phreatoicus* and *Notamphisopus)*.

3. Antennules

A multi-jointed filiform condition of the antennule is, also, one which from its wide occurrence in Malacostraca might reasonably be expected to prove a primitive character. In the Peracarida the multi-articulate condition of this appendage persists in Mysidacea, many Amphipoda and in the Apseudidae. It occurs, also, in widely separate sub-orders of the Isopoda, but on the whole, in this latter group, the antennule is short or very short. But in all Phreatoicids (even in those in which a many-jointed flagellum is found in adult life), the young (where known) emerge from the brood-pouch possessed of a short, club-shaped antennule with few joints. It would be arguable, therefore, that in this sub-order such a multi-articulate condition of this appendage is an independent reacquisition due to adaptation to more active (or more exposed) mode of life and *not* the retention of a primitive character. Against this view is to be set the fact that a many-jointed condition in the adult occurs only in species in which it is linked with a preponderance of other, undoubtedly primitive, characters. Thus it is highly probable that it should be included in the category of primitive characters and that the short, club-shaped antennule of sub-alpine Australian

genera is correctly to be interpreted as a stunted condition, the persistence into adult life of a larval phase[1]; that the antennule has the club-shaped condition in some species of the South African *Mesamphisopus* seems to be a parallel case of retardation of development under similar sub-alpine conditions; its recurrence in various unrelated subterranean forms is open to the same explanation.

4. Antennae

These, as in most Isopoda, have a peduncle consisting of five joints, of which two constitute the protopodite. The insertion is immediately below the eye and at its attachment the antero-lateral corner of the head is marked off above by a variably developed 'sub-ocular incisure', while below a well-marked ridge (in some cases, a groove) completes the boundary of a 'sub-ocular' area, suggesting the existence of a proximal protopodite joint[2] incorporated in the head which would give six joints to the peduncle and a third to the protopodite. In *Asellus*, where only five joints are seen, the missing joint is said to be the third which is incompletely fused with the second free joint; but in the *Asellidae* it should be noted, a sub-ocular incisure is not seen nor a sub-ocular area indicated. This well-marked sub-ocular area may be regarded as possibly a vestige of the more primitive condition in which six free peduncular joints were developed. The relative length or shortness of the antennae varies greatly in different species. In *tasmaniae*, for example, they may be as long as the body and many times longer than the antennule; species which have wholly adopted subterranean aquatic life also carry very long antennae, while in *terricola*, *latipes* or *kershawi* they are short, not greatly exceeding the antennule. It seems probable that the intermediate condition (with antennae of moderate length) was that of the ancestral form.

5. The Mouth Parts

Chilton, in his account of *P. australis*, gives the first detailed description of these structures in a Phreatoicid, and recognizes the very evident likeness of the several appendages to the corresponding parts in *Asellus aquaticus*, so faithfully described by Sars (1867). That such a likeness between *P. australis* and *Asellus* spp. exists is not denied, but it is noteworthy that in Chilton's earlier account (of *P. typicus*) there was made no suggestion of any likeness whatever to the *Asellidae*, although almost every other Isopodan group was brought into the comparison and resemblances, even to Amphipod and Tanaid were noted. But *P. typicus*, notwithstanding its extreme specialization to subterranean life, nevertheless retains a less reduced, and, *therefore*, a less Asellus-like condition of the mouth parts. The fact seems to be that only in the reduced mouth parts of the more specialized Phreatoicids such as *P. australis* does the condition of these appendages make its closest approach to that of the Asellidae, and, if there should be any near phyletic relationship between the two groups (which is open to question), it might be feasible to derive the Asellids from an ancestral Phreatoicine stock rather than the reverse. It is more probable, however, that the relationship is but a distant one and these 'likenesses' may most reasonably be explained as due to parallel development in widely separated sub-orders. Indeed, this is to be expected where these creatures are living under closely comparable conditions and

(1) There is an analogous condition in the subterranean *Cruregens* which retains throughout life the larval condition of *six* peraeopoda only.

(2) But Bouvier (1902) and Hansen (1903) regard this as part of head and find a free first joint succeeding this (in *Bathynomus*, etc.).

both may be presumed to have inherited from a primitive Malacostracan ancestor those tendencies that have brought into being what Dennell (1937) calls a 'Peracaridan series' of feeding mechanisms. Although there are numerous minor differences between the mouth parts of the Phreatoicidae, they exhibit in general a condition which seems clearly to have arisen by a simplification of that which prevails in the Amphisopidae. In the latter family, while there is rather more variation in structure of the mouth parts, the condition is, nevertheless, one which could, in the main, be derived from that still persisting in the Mysidacea. It is, of course, improbable that the Phreatoicids had their origin from a Mysid stock, but the condition of the mouth and its various parts may, nevertheless, best be discussed by reference to, and comparison with, those of the Mysidacea.

Mouth, Food-basin, and Food Current.—It will be noted that, while the topography of the oral region (fig. 1) is, in general, like that of *Hemimysis* (Cannon and Manton, 1927, text fig. 1), two important differences may be distinguished. In the first place, the 'oral cavity' appears *relatively* more spacious. This is almost certainly correlated with the marked antero-posterior elongation of the body of the mandible in the Phreatoicids, whereas in the *Anaspididae*, in *Mysis*, and in *Apseudes* that appendage appears elongated in the dorsi-ventral plane. The mandible, too, seems to have developed a different type of articulation (see below, p. 11), which suggests that in Phreatoicids it may be capable of much more

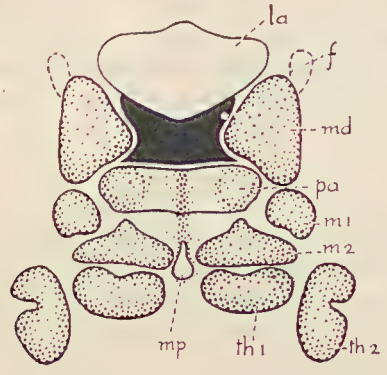

FIG. 1.—Ventral view of head of *Synamphisopus ambiguus* (Sheard) after removal of paired appendages.
The dark area indicates approximately the upper oral region.
m.1., maxillula; m.2., maxilla; mp., median process; th.1., maxilliped; th.2., gnathopod; other letters as in list on p. 5.

varied and complicated movement. Secondly, the succeeding mouth parts seem much more crowded together in a linear series. The paragnaths seem relatively more bulky, although their bases apparently do not extend so far posteriorly; the maxillula and maxilla of the Phreatoicids may retain (apart from the loss of palp and exopodite) the complexity of setal armature characteristic of the filtratory mechanism of other Peracarida, but have shifted their positions relative to each other. The maxillae (and maxillipeds) are closely approximated in the middle line (figs 1 and 2), and the maxillulae appear to have been squeezed out, to lie antero-laterally to the maxillae. Consequently, the spacious 'food basin' of such a form as *Hemimysis* is, in the Phreatoicids, represented by a greatly restricted cavity, being both short and narrow, while the 'food groove' which opens into it from behind is split (in some species at least) by a short, bent,

median process, undoubtedly the homologue of the structure so named in the Cumacea and not apparently recorded outside that sub-order, except in *Lophogaster* (Manton, 1928, *fide* Dennell, 1934).

The progressive crowding of these posterior mouth appendages (fig. 2), while it may be partly due to a shortening of the head, is more probably the consequence of a forward displacement of the first peraeon (second thoracic) segment and its appendage, the coxa of the gnathopod having in some species shifted its attachment to a position external (lateral) to that of the maxilliped instead of, as in *Hemimysis*, well behind it. To the comparable displacement in *Apseudes*, Dennell (1937, text fig. 1) has attached great importance, the forward movement being regarded, in that genus, as having a special significance in connexion with the respiratory (and feeding) current. Since such an explanation will not serve for

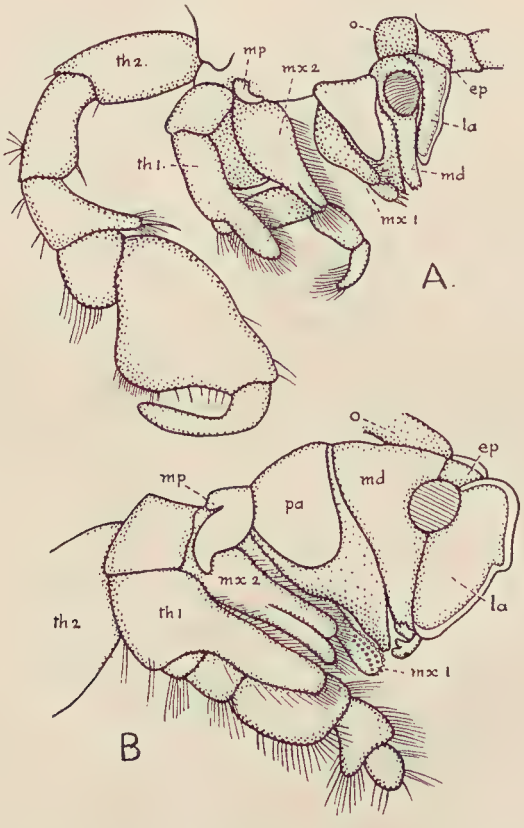

FIG. 2.

A.—Median section through the ventral part of the head of *Phreatoicus tasmaniae* G.M.T.
B.—A similar median section through the ventral part of the head of *Phreatoicopsis terricola*, Spencer and Hall, to show increased crowding of mouth parts.
o., lower end of oesophageal tube; other lettering as for text-fig. 1.

Phreatoicids (respiration in this sub-order being the function of the pleopods), it may be suggested that it is an expression of the tendency towards more complete cephalization which is exhibited in varying degree in different orders of Crustacea and which has become so strongly developed in the Decapoda.

When the problem of the process of feeding in this group was first considered, it seemed probable that the movement of the pleopods in the relatively deep and narrow channel formed by the pleura of the pleon (a channel extended forwardly in some genera by the expanded bases of the adjacent peraeopods) might establish a current sufficiently strong to be effective as a 'food current', which, however, if it existed, would have functioned in fashion quite unlike that of Mysids. It proved unexpectedly difficult to observe accurately the feeding of these animals, since under natural conditions they feed only when at rest partly buried in the mud, but it has been found (in *P. palustris*, at least) that, although the waving of the pleopods is incessant, the movement, at rest, is so very slight that any current so set up is practically negligible. It can just be detected as a gently ingoing stream at the bases of the hinder peraeopods, the escaping water issuing from beneath the telson; experiments did, however, establish the fact that this movement of the water is not sufficient to disturb appreciably even the lightest of visible particles in the neighbourhood of the mouth. Nevertheless, since the maxillula and still more the maxilla and maxilliped are frequently found clogged with particles, it is practically certain that these appendages play an important part in the collection of food, and, since it is evident that there is no food current established by the swimming and respiratory pleopods, it seems obvious that the mouth parts themselves must be both the cause of the movement that disturbs the fine silt as well as the sieve that collects the disturbed particles. The setting in motion of the particles may, however, in part at least, result from the disturbance of the mud by movements of the head of the animal as it lies partly buried, or even of those of the anterior peraeopod, although, so far as the animal can be observed, it seems quiescent while feeding, except for a continual waving of the epipodite of the maxilliped. It is possible, therefore, that the absence of an overhanging carapace (so essential a structure in the more efficient of the filter-feeding mechanisms) is, perhaps, in part compensated in the Phreatoicids by the large development of the epipodite of the first thoracic appendage.

The various parts of this feeding mechanism must now be considered separately.

The *labrum* is relatively stout and comparable to that of *Hemimysis* or *Paranaspides*. It articulates with the epistome above by a variably irregular suture, and the whole structure exhibits a pronounced asymmetry doubtless in relation to the unequal condition of the mandibles. It is strongly and unevenly notched on either side, these gaps accommodating the mesial surface of the second joint of the mandibular palps and (in some species) the free end of the 'fulcral' process of the mandible. There seems to be no previous record of such an asymmetrical condition of the labrum either in this or any other Peracaridan group, although passing mention is made of asymmetry *in the posterior edge* of the labrum (which forms the anterior border of the functional mouth) in *Hemimysis* (Cannon and Manton, 1927, p. 223). The anterior face may bear a sub-median ridge which in some species rises to a blunt elevation, perhaps the rudiment (or the vestige) of the sub-rostral spine of Dennell's account of *Apseudes*. On either side of the ridge the surface may be concave, emphasising the low central elevation. In some Amphisopine forms, there is a characteristic, curved and interrupted, transverse row of long setae which forms a conspicuous moustache-like sub-marginal fringe.

The hinder wall of the 'oral cavity' is provided by the *labium* or *paragnaths*. This, too, agrees fairly closely with the condition figured for *Hemimysis* by Cannon and Manton (1927, pl. 2, fig. 2A), except that, in Phreatoicids the distal free border is not strongly bent forwardly. This posterior wall is incomplete

distally, being cleft in the middle, the gap apparently enlarging or diminishing with the separation or apposition of the two lateral halves. The free ventral edge is very heavily fringed with short, stiff, curved setae, and, in the Amphisopine forms, a feature of unusual interest may be made out, for hidden among these fringing setae, there are, apparently, a number of short setospines. So dense is this fringe that it is most difficult to satisfy oneself that these spines really exist, but in some mounted preparations there has occurred considerable retraction of the living substance, and, in such cases, there seem to be (immediately within the chitinous covering) small heaps of protoplasm evidently withdrawn from the spines. If they have a real existence, it would seem possible that they are vestiges of a series of lappets of which, in *Apseudes*, only a single but well-developed pair remains; and in one Phreatoicine genus at least, these lappets seem to be represented by a single apical pair only.

It is in the *mandibles* (fig. 3) that we find the first notable departure from the Mysidacean or Syncaridan condition. These appendages form the lateral walls of the functional oral chamber and their bodies have undergone in the members of this group a considerable antero-posterior elongation which appears to be less, however, than in *Asellus*. Its actual articulation is seen on the lateral or ventro-lateral border of the head as a comparatively short hinge line which may be horizontal or inclined obliquely. Internal to this hinge is an opening, variable in size and shape, through which the adductor muscle passes from its origin within the head. The movement of the mandible is, however, not merely a swinging one upon this support, but is modified by two outlying parts of its body, these being variably developed in different species. Anteriorly (and internally to the palp) there is a projection, angular, conical, or rounded, which fits into a related hollow below the sub-ocular area or onto the labrum or even the epistome. This projection is here referred to as the 'fulcral' process. Posteriorly, at a variable distance from the hinge, the body of the mandible projects postero-ventrally in a truncated free end which is concave where it abuts against the maxillipedal region of the head. This concave 'acetabular' process apparently moves upon a corresponding boss projecting from the head. So, at both ends of the body of the mandible, there is a feeble 'ball and socket' joint, and these, together, must modify the movements of the limb and probably contribute to the more effective grinding action of the molars. In some species (e.g., *littoralis*) the animals are often found preserved with the mandibles forwardly displaced so that the dentate edges are visible in front view, meeting in a nearly vertical plane immediately below the labrum. Normally, however, the teeth of the cutting edges meet in a horizontal plane behind the border of the labrum and, therefore, are visible only when examined from below. The possibility of such a difference in the position of the mandibles at rest is probably due to differences in the degree of mobility as determined by the size and position of the fulcral and acetabular articulations. Behind, and below the lower end of the acetabular process, the head may be forwardly produced into a buttress for the mandible, this being almost certainly the vestige of the structure so well developed as the setose 'posterior process' of the head in *Asellus*. In *tasmaniae*, there is a fine fur of setae here, but in other species, this process is unarmed and, in many, it is not developed.

The persistence of the 'lacinia mobilis' on the right mandible characterizes many species, and since such a condition is common to Syncarida as well as to members of several of the Peracaridan sub-orders, it must be accepted as a primitive character and its loss ascribed to an independent specialization within the group. It is likewise retained in the Cirolanidae, but in other Isopoda it appears to be generally wanting on the right mandible, so that its absence in the

Asellota cannot be considered as an indication of closer kinship with the Phreatoicine than with other Isopoda, while its occurrence in the Amphisopidae is evidence that the Phreatoicoidea are not derived from Asellote forms. In Amphipoda, as in Phreatoicoidea, a parallel evolution has taken place, both or only one (the left) of these laciniae being retained.

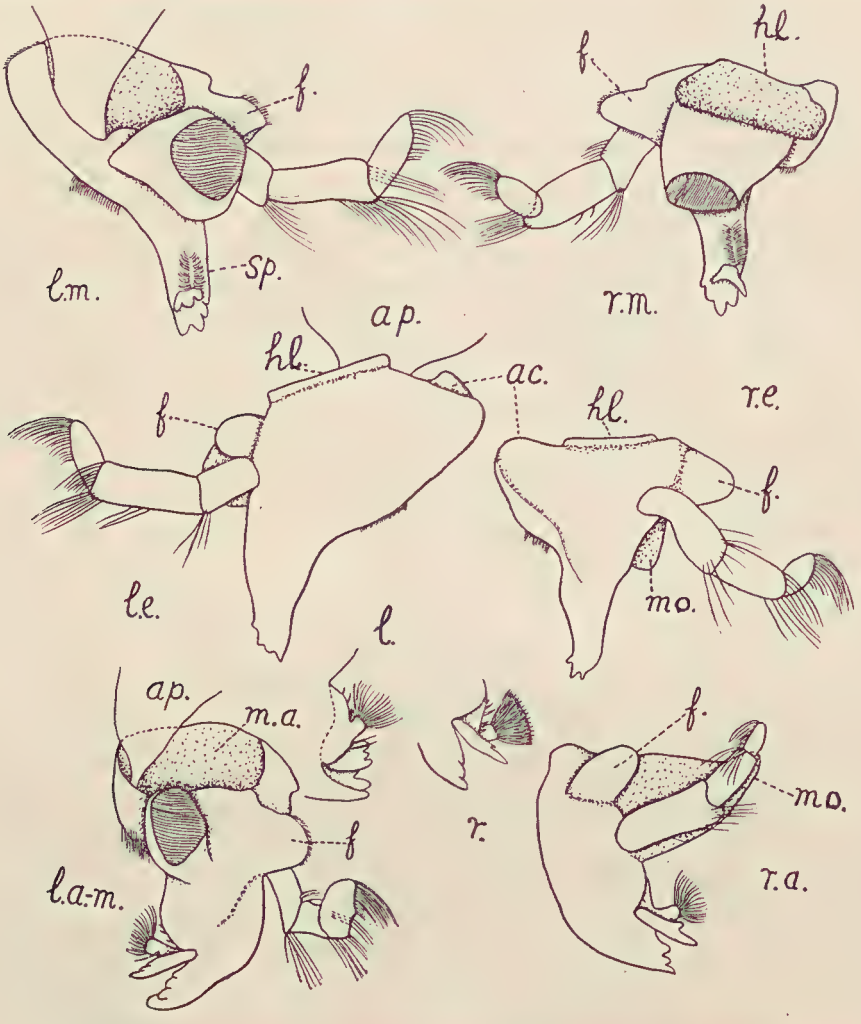

Fig. 3.—Mandibles of *Synamphisopus ambiguus* (Sheard). (For explanation of lettering see p. 5.)

The palp shows considerable range of structure. It retains the full number of joints found in Malacostraca and these may be sub-equal in length; alternatively, the first, the third, or both of these, may be considerably shortened. In Mysids, the palp has a quite short first joint, an extremely long second joint and the third is of moderate length and greatly widened. There can be little doubt that in these proportions of the mandibular joints, *Mysis* shows a specialised condition, and it seems probable that the more primitive condition was one in which the joints were cylindrical and of approximately equal length. In its setation, however

(as in that of other mouth parts), *Mysis* may have retained a generalized arrangement. The second joint has setae along both its entire mesial and lateral borders as well as a terminal comb, while the third joint is sickle-shaped, with several rows of setae along the outer concave border and a fur of fine setae clothing its mesial aspect. Such a condition is approached quiet nearly in *tasmaniae*, where in one specimen there is, also, a large median sub-terminal seta reminiscent of the long and peculiar terminal seta of *Mysis*. In most other Phreatoicoidea the second joint is less fully armed, the terminal joint rarely has more than a single row of setae, and this row may greatly diminish in length while denticulate spines may replace pectinate setae.

Alongside the palp, immediately external to its basal joint, there was found, in two New Zealand specimens, a slender rod-like process, unjointed but otherwise closely resembling that which Smith has recorded as a vestigial exopodite in *Paranaspides*. Whatever it may represent, it is evidently of rare occurrence in this sub-order.

Maxillula. The description of the maxillula given by Sheppard for *tasmaniae* omits certain essential details of setal armature. A close examination of this appendage suggests that upon the endites there is retained a condition much more closely approaching that of *Apseudes* and of *Mysis* than existing descriptions would lead one to suppose.

It is generally recognized that among the smaller Crustacea, it is not unusual to find, associated with marked decrease in size of the animals, an increasing structural simplification of the mouth parts and reduction of armature, and therefore, while the retention of little-reduced and closely comparable mouth parts may fairly be considered as positive evidence of relationship, a marked decrease in the number of setae, spines, etc., does not preclude the possibility of comparatively close kinship. Thus the figures given by Sars (1867) of the condition in *Mysis relicta* show that the armature of this appendage has undergone some reduction as compared with the larger, but closely related, *M. oculata*. In the little *Hemimysis lamornae*, the figures of Cannon and Manton indicate that this reduction has been carried still further. It is of interest, therefore, to find that, while in the Phreatoicoidea simplification of the mouth parts has occurred, it seems not definitely related to decrease in size.

In *Mysis oculata* (fig. 4A)[1] the inner (proximal) endite is short and wide, its bluntly-pointed apex fringed by a row of slender spines directed both mesially and laterally; these are relatively numerous (fifteen), but only about eight (those mesially situated) are setospines, the lateral members of the series being stout and pectinate or feebly plumed. On the posterior face of the endite, and sub-terminal in position, is an irregular row of slightly pectinate or feebly-ciliated spines. Upon the outer (distal) endite, there is a treble row of terminal spines, and on its posterior face, also, is a sub-terminal row of about eight feebly-plumed setae. In *M. relicta* and *H. lamornae*, these same ranks of spines and setae are present, but with progressive reduction. Thus, in the latter species, it is stated that on the proximal endite there are *three* only of the terminal setospines, while of the sub-terminal rows on the posterior face of both endites in this species, as well as in *M. relicta*, there seem to be but three or four spines or setae.

In the Phreatoicoidea (fig. 4B), the general conditions are much the same, but the *shape* of the inner endite has been greatly modified, the lateral half (with

(1) Figures by Hansen of maxillula and maxilla of *Mysis oculata* occur in several text books (e.g. Calman, 1909), but reference to Hansen's paper is not readily found. Apparently details of setal armature were not furnished and the figures here given are drawn from preparations made from specimens of *M. oculata* kindly supplied by Prof. Hanström of the University of Lund.

its fringe of feebly-plumed setae) having apparently disappeared. Generally, it will bear a larger number (ten to six) of setospines in the Amphisopine forms and a smaller (four to three) in Phreatoicinae; the sub-terminal row of spines varies in numbers from four to two and it has shifted to a position practically apical. The outer endite is less modified and may still retain a threefold[1] row

FIG. 4.

A.—Part of maxillula, in posterior view, of *Mysis oculata*.
B.—Part of maxillula, in posterior view, of *Amphisopus lintoni*.

of terminal spines, but these may decrease to a double rank; the sub-marginal plumose setae, however, retain the position found in *Mysis*, but they are never more than four in number and may be reduced to two or one. In a few species, this series seems to have vanished completely. The fact that in *Mysis* and in the Tanaioidea (as well as in some sub-orders of Isopods) both of these rows of spines and of setae on both endites are well represented lends further support to the view that the occurrence of a small number only in some Phreatoicids (and Asellids) is to be interpreted as due to reduction, while the retention of the more complete series represents most nearly the primitive condition.

Maxilla. A similar story is to be told of the maxilla, but here the reduction in *M. relicta* from the condition retained by *M. oculata* is more marked. Fig. 5A represents an anterior view of the maxilla of this latter and should be compared with the figures given by Stebbing (1893, p. 272, fig. 23) for *M. relicta*. In *M. oculata*, the outline of the rounded basal lobe of the proximal endite is much more definite, its mesial edge has the characteristic comb-like row of close-set filtratory setae (fil.), but, in this species, the row is continued around the margin onto the anterior face of the endite, almost to the junction with the base of the palp. Sub-marginally, too (upon the anterior face), is an irregular row of about

[1] In *P. terricola* there are actually four ranks present, although not all of these are complete.

seven stout plumed spines *(a.s.)*, of which, in Sars' figure of *M. relicta*, only three are shown as persisting. In Phreatoicids this sub-marginal series has practically disappeared, only one of these (apparently the most mesial) being retained, and this one very variably. In some species of Phreatoicids, however, there is an entire line of fine setae anteriorly paralleling the filtratory (*a.s.*, in figs 5C and 5D).

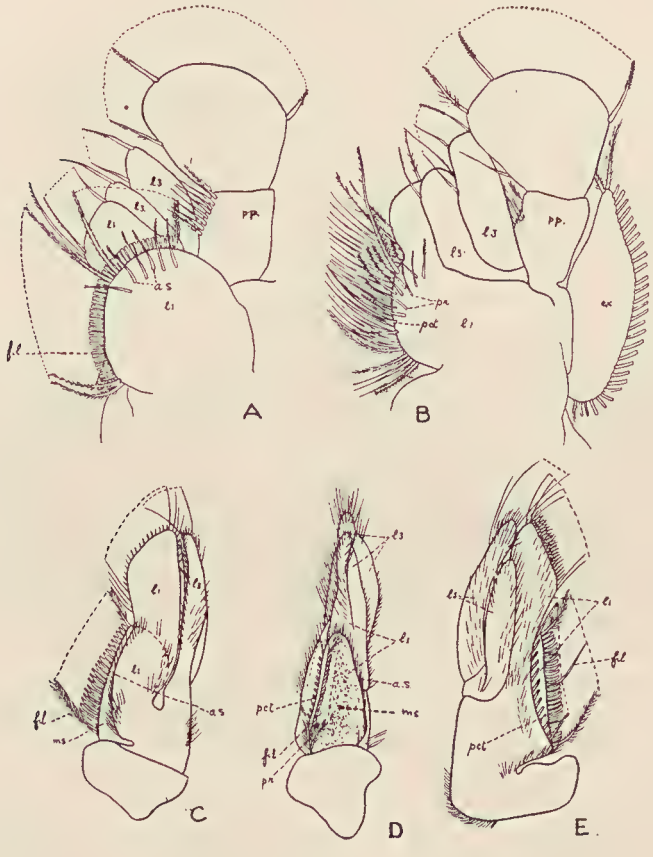

FIG. 5.

Maxilla of *Mysis oculata* (A, anterior view; B, posterior view).
Maxilla of *Synamphisopus ambiguus* (C, anterior view; D, mesial view; E, posterior view).

The distal part of the proximal endite is relatively large and appears better defined in *M. oculata* than in *M. relicta*, where it is shortened and set at a lesser angle. In both species, the mesial edge of this distal region is armed with a series of pectinate setae, the continuation of a rank which arises near the base of the rounded proximal region (fig. 5B, *pct.*) immediately adjacent and posterior to the filtratory setae. It is this posterior row of setae which is said by Cannon and Manton to serve in protecting the filtratory setae from the action of the brushing setae on the maxilliped. In the Phreatoicoidea both these rows of setae

occur with the same general arrangement, fringing the posterior edge of a sub-triangular mesial surface. The anterior edge of this surface may also bear a rank of setae—usually simple—well developed in *Synamphisopus*, but the proximal endite itself shows a considerable range of variation. The rounded basal part is variably marked off from the apical portion: the filtratory setae may be confined to this basal part which may be considerably reduced, or the two portions (basal and distal) may no longer be distinct but pass smoothly one into the other and the filtratory setae may then range almost to the apex.[1]

Viewed from behind, there is in *M. oculata* another (a fourth) series of setae (fig. 5B, *pr.*), sub-marginal in position. In some Phreatoicids a belt of setae occupying a comparable position may represent this hindermost series (fig. 5D, *pr.*).

The two endites of the third segment of *Mysis* resemble closely the distal part of the proximal endite and the armature is similar. This is equally true of many Phreatoicids, although in this region, too, a good deal of variation may occur, and since in the Phreatoicids the palp has disappeared, there is a tendency for the outer of these two endites to move anteriorly (into the place of the missing palp) and partly to ensheath the middle plate.

At this point, the likeness between *Mysis* and Phreatoicids ends, for, in the latter, palp and exopodite (both of which play essential roles in the filtratory mechanism as interpreted by Cannon and Manton) are absent. Distinct tufts of setae are present however, and may mark the position of the vanished structures.

The Phreatoicid maxilla seems closely to resemble the condition figured by Dennell for this appendage in *Apseudes talpa*. In that form the basal and distal parts of the proximal endite are represented as very like those of *Mysis* and of some Phreatoicids, and Dennell apparently gives no reason for the suggestion (in his figure) that this distal part of the first endite has united with the inner endite of the third segment. That this latter endite has vanished would seem a more probable explanation, but external to the proximal endite two structures are shown which appear to be exactly comparable with the two endites of the third segment of *Mysis* and of Phreatoicids; the outermost is, however, in *Apseudes*, indicated as the palp.

Median process (fig. 2, *mp.*). Immediately behind the maxillae, in the middle line, there occurs in several Phreatoicid species a small bent process, homologous with the median process so conspicuous in Cumacea. According to Dennell, it has been found by Manton in a rudimentary condition in a primitive Mysidacean *(Lophogaster)*. Reference to this structure will be made at a later stage.

Maxilliped. In most Phreatoicids, this appendage has its attachment very close to the maxilla. The coxae in some species are relatively long, but as a rule this joint is shortened. In the female it bears a large lobe projecting stiffly backwardly into the brood-pouch, its free edge furnished with a fringe of slender plumed or recurved setae. This plate is found in a reduced condition in the males of some species. Each basis bears a long endite produced anteriorly and dorsally, those of opposite sides being linked together by a longer or shorter series of coupling hooks which obviously are modified members of the series of pectinate spines which arm the ventro-mesial border of the endite.

The dorsal (morphologically anterior) edge of the endite bears a row of plumose brush setae which may extend the length of the endite or be restricted to its distal part. From the latero-distal angle of the basis springs a stout plumed spine which probably marks the point where the exopodite once was carried.

[1] *Asellus* shows an advanced stage in the specilization of this endite.

The palp varies in length; in some species so long that the distal joints may be upturned in front of the labrum.

Throughout the sub-order, the epipodite is well developed, springing by a wide base from the lateral aspect of the coxa.

6. Cervical Groove and Maxilliped Segment

Near the hinder border of the head, there is normally a transverse groove running dorsally from the postero-inferior angle. In some forms, e.g., *Mesamphisopus* (fig. 6, *2s.*) this can be readily traced to the actual ventro-lateral border. In many cases, it is but feebly developed and may rise from the posterior, rather than the ventro-lateral border, and only in *brevicaudatus* does it meet its fellow dorsally—in all other cases being incomplete. In the majority of Amphisopine forms it is practically obsolete. There can be little doubt that it marks the original boundary between the segment bearing the maxilliped and the primary head in front; the segment widens above, where it may show the vestige of a segmental transverse ridge, but below may be reduced to a very narrow edge.

7. Transverse Ridges on Peraeon

The occurrence on the segments of the peraeon of strongly marked transverse ridges armed with stout setae or spines is comparatively rare in this group. It occurs notably in a few Great Lake species, while in *Eophreatoicus* there is a marked and comparable wrinkling which extends onto the pleon segments, also. It is more usual to find the body somewhat feebly wrinkled or practically smooth, this latter particularly in subterranean forms. It is of interest, however, to note that in many, including some of these underground species, the distribution of setae is suggestive of the obsolescence of such ridges. In the one specimen of the fossil *wianamattensis* which has been examined and which displays the dorsal view, a strong wrinkling near the forward and hinder border of the peraeon segments was evident. It seems highly probable that such ridging was developed in the ancestral Phreatoicid, and in this connexion it should be noted that in Packard's restoration of *Acanthotelson* there is a suggestion of a similar condition, as also in Calman's figure of *Pleurocaris annulatus*, which was, according to that author, closely related to *Acanthotelson*.

8. Expansion of First Peraeon Segment

The expansion of the first peraeon (second thoracic) segment (widening latero-ventrally) and its union with the head (a vestigial condition of a carapace which does not, however, hang free below) might be regarded as a condition retained in the more primitive members of the group, the last trace of this part of the caridoid facies. This tendency to expand the first peraeon segment ventro-laterally occurs, however, both in those forms in which the head is short and all traces of the cervical groove have disappeared as well as in those in which the head is longer and the maxilliped segment well-defined or even nearly complete and in which, too, the first peraeon segment is still free. Again, a choice of two explanations is available. It is fairly generally accepted that the caridoid facies (which includes a well-developed carapace) has undergone retrogression to a variable extent in the Syncarida, Amphipoda, and Isopoda. If that be so, it may be considered that it is the short-headed (Amphisopine) form which most nearly retains the ancestral condition, the structure of the Phreatoicine forms being derived by still further recession from the caridoid type; the first peraeon segment

regains its freedom from the head and may become secondarily elongated till it equals or exceeds the length of the succeeding segments (particularly in elongate subterranean forms) and the maxilliped segment reappears, till it may be practically as much in evidence as in the more primitive Syncarida—this view supposing as possible a reversal of evolutionary tendencies and the recovery of lost or nearly lost structures. In the alternative, it may be supposed that, in this feature, the Phreatoicine condition is the more primitive, that a carapace (if once present in the evolutionary history of this sub-order) was a backward development of the head only and left free, beneath it, all the thoracic segments (including that of the maxilliped) so that it could disappear (as is supposed to have happened in the Syncarida) without affecting thoracic segments; the latter view would suggest for the Phreatoicids a kinship, or at least a parallel evolution with the Syncarida.

Another point of interest in this connexion is that this widening of the first peraeon segment ventrally is usually associated in the Amphisopidae with a greatly-developed coxa of the gnathopod—the coxa having come to lie externally to the base of the maxilliped as it does in *Apseudes* and the Cumacea. It is difficult to believe that this was the earlier condition which is disappearing (by backward shift) in the Phreatoicinae.

In those Phreatoicids which seem in many respects to be the most primitive of living species, *M. capensis* and *E. kershawi*, the first peraeon segment is not at all, or very little, expanded below.[1] In the former, the coxa of the gnathopod lies so far back as to leave wholly uncovered the maxilliped segment and even, in some specimens, to expose the postero-ventral corner of the head. This is true of *Hyperoedesipus*, also. The *fusion* or the *freedom* of the coxae of peraeopods is related to this matter. It would naturally be supposed that the freedom of these joints was the primitive state and the fixed condition a later development—yet *Mesamphisopus* shows them seemingly united to their segments, while they reach the greatest degree of freedom in the Phreatoicidae.

9. Vestigial Structures on Peraeopods

Upon the antero-proximal border of the basis of the second, third, and fourth peraeopods of *E. kershawi* and probably in the fossil *wianamattensis*, there is developed a strong boss armed with a cluster of stout spines, and this may be developed even when the remainder of the basis is unarmed. It seems possible that there is here the last trace of a vanished exopodite, for it is in this position (i.e., near the proximal end of the basis) on the more anterior peraeopods that the exopodite is found in some Tanaioidea. In certain members of that order, the exopodite is reduced to small tufted knobs differing, in degree only, from those found in some Amphisopidae.

10. The Hinder Peraeopods

The Phreatoicids are quite exceptional among Isopoda in that the body appears compressed. While this appearance is due in part to the downward extension of the pleura in the pleon, an expansion of the bases of the three hinder peraeopods contributes largely to enhance it. The forms in which this condition is well developed are those capable of swimming strongly, and there can be little doubt that this deepening of the channel in which the pleopods sweep makes these appendages more effective as natatory organs.

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[1] According to Barnard (1914, p. 234) it is in *M. capensis* actually longest in the mid-dorsal line.

In *Eophreatoicus* other joints than the bases are also expanded. In Amphipoda the enlargement of these more distal joints is frequently associated with the burrowing habit, but this explanation apparently will not serve for *Eophreatoicus*, which is said to be found swimming in cold, clear water. *Phreatomerus latipes*, too, was taken swimming against a strongly flowing current.[1] The Triassic fossil *wianamattensis*, likewise, shows the bases of all peraeopods moderately expanded, as well as the merus of some at least of the anterior limbs, in this resembling *Eophreatoicus*. Walking or creeping Phreatoicids (including subterranean forms), on the other hand, usually have the bases little widened, and in some species the whole leg is slender. There are, however, exceptions to this rule, the bases of the fifth to seventh peraeopods being moderately wide, for example, in *pearsoni*, *australis*, and *assimilis*.

It seems probable, then, that the hinder peraeopoda of the primitive Phreatoicid had more or less uniformly widened bases, which have undergone a varying degree of reduction in most Phreatoicidae, whereas in the majority of surface-living Amphisopine forms, the bases of the hinder peraeopods have become increasingly expanded.

11. Oostegites

In the retention of functional oostegites on the first four peraeon segments, associated in some species with what are almost certainly vestiges of these upon the maxilliped (the 'coxal lobe'), and (in one or two genera) of vestiges of a more posterior pair on the fifth peraeon segment, we have in this group a better development of these structures than in most of the Peracarida. In some of the Mysidae—in so many features primitive—this particular character is found to be highly specialized, the brood-pouch reduced and oostegites restricted to a few (the hindermost) peraeopods, but in several Mysidacean families seven pairs of thoracic oostegites are found, a condition seen in the Carboniferous *Pygocephalus* and almost certainly that of the primitive Peracarida. In the Isopoda some Cymothoidae (e.g., *Æga*) are said to retain the full seven pairs, but sixth and seventh are small.

Concerning the homologies of these structures, Claus (1885) has suggested that they may perhaps be modified epipodites, a suggestion which, while it is in keeping with their origin from the coxa, requires that they should have shifted from the outer to the inner aspect of that joint. That may have come about by a rotation, in the first four, of the entire limb, and it is noteworthy that these, if expanded, are widened anteriorly. In many, a partial rotation still exists. The failure, in the hinder three, to undergo this rotation would explain the division of the legs into two groups. Such an explanation might perhaps serve equally well to explain the presence of gill as well as of oostegite in the Amphipoda as outgrowths of this coxal joint (and equivalent to the *two* epipodites of the Syncarida), but a difficulty would arise in the case of those quite numerous Amphipods in which *two* gills are present in relation to each limb (as well as oostegite in female) unless we suppose that the two gills have come about by the subdivision of one epipodite.

As an alternative, it seems possible that the oostegite might be a much modified gnathobase and that the coupling lobes of the pleopods are equally derived

[1] It is of interest that in localities where Amphipod (Neonipharigid) and Phreatoicid occur together, they may usually be readily separated by emptying the debris picked up by the scoop upon the slope of a boulder. The Amphipods will usually slide and scramble *down* the slope; the Phreatoicids clamber upwards *against* the downward trickle of mud and water.

from these same structures co-existing, in the pleopods, with a normally placed epipodite. It is possible, too, that the coxal structure on the seventh peraeopod of the male, into which runs the vas deferens, should be regarded as a still more modified member of this series which would then extend, almost without an interruption, from maxilliped[1] to fifth pleopod. Such a derivation, whether from gnathobase or epipodite might explain the occasional development of brood lamellae in the male or of penes in the female, these structures having arisen from appendages primarily unrelated to sex.

12. Median Sternal Processes

The occurrence of one or more median sternal processes is probably to be explained as the retention of a part of a linear series, once perhaps segmental in character in an ancestral Peracaridan. Such median sternal down-growths occur in some Gammarids, Caprellids, Anthurids, and in the Tanaioidea.

In *Hyperoedesipus* and *Phreatoicoides*, laterally compressed median spines occur somewhat variably on the peraeon segments; in *Eophreatoicus* and *Amphisopus*, a median elevation on the first pleon segment, and sometimes on the second also, is probably a remnant of this same series; in *Phreatoicopsis terricola*, in addition to the median process just anterior to the maxillipeds, there is found a stout conical boss between the gnathopods and others on the first four pleon segments. In *M. tasmaniae* (G.M.T.), the median process on the head and two processes (on the first and second pleon segments) appear; in *M. setosus* sp. n., the median process is particularly well developed. In *Synamphisopus ambiguus* (Sheard), only this anterior member of the series persists and there can be little doubt that this is the structure which has been modified and pressed into service as a mouth part in the Cumacea.

13. Pleopods

It would seem that the primitive condition of these appendages must have been one in which *the two lamellar rami were equal in size, similar in shape and both fringed with the typical (natatory) plumose setae*, a condition characteristic of Apseudidae and many Isopoda and one which, in the Phreatoicoidea comes nearest realization in *Mesamphisopus*. In this genus, as in all Phreatoicids, an almost exact similarity in shape is restricted to the first pleopod, the succeeding pleopods all showing an exopodite freely separated into two lobes, a condition hinted at, but nowhere so well developed in other Isopodan sub-orders (Anthurids, Cirolanids, Asellids, and Stenetriids) as well as in some Apseudids. Apart from this difference, however, the two lamellae are, in *Mesamphisopus*, very similar in length and breadth; the endopodite, though decreasing somewhat in size, retains, in all the pleopods, a variable number of the plumose setae, which, however, show an increasing tendency to become simple in the more posterior appendages. In *Notamphisopus*, too, the first pleopods show this presumably primitive shape and both lamellae are more nearly equally setose, but in the succeeding pleopods one lamella (the endopodite) is bare of setae and decreases progressively in size. In *Eophreatoicus*, which appears in many respects to be primitive, this practical equality in size and similarity in shape is preserved in all the pleopods, but the fringe of plumose setae is wholly wanting from all the endopodites. The persistence of

[1] The co-existence of epipodite and oostegite (coxal lobe) upon the maxilliped is not incompatible with the above suggestion, for while the epipodite retains its normal lateral position the coxal lobe arises from the posterior (morphologically external) surface, but it is nevertheless, mesial in position and could correspond with a gnathobase.

plumose setae upon the endopodite of the South African *Mesamphisopus* and the New Zealand *Notamphisopus* has a feeble counterpart in a Tasmanian species, *Hypsimetopus intrusor* Sayce, where three or four plumed setae persist apically on the first pleopod. Since these setae are obviously the remains of a natatory apparatus in forms, none of which now retain the free swimming habit, while in many of the Amphisopine forms, which are strong swimmers, this setose condition of the endopodite has disappeared, the retention of these non-functional vestiges in three widely separated genera has clearly an important phyletic significance. The penial stylet which is developed from the mesial border of the endopodite bears, in many species, setae and spines, a retention possibly of the setae which formed the primitive fringe of that border.

It should be noted that in *M. tasmaniae*, the exopodite of the first pleopod is unusual in that it bears laterally a few stout marginal spines as well as setae; in *Hyperoedesipus*, alone, are plumose setae retained along the whole length of the *mesial* border in the first pleopod, while in *Hypsimetopus* this border is bare of setae.

The epipodites found in Phreatoicids upon the third, fourth, and fifth pleopods constitute a feature peculiar to this sub-order. What may perhaps be traces of these, fused with the sympodite of first and second pleopods, are found in several genera, but only in *Eophreatoicus* is there found a fully-developed free epipodite upon the second pleopod, once again, it must be assumed, the retention of a more ancient condition.

14. Coupling Hooks

The presence of coupling hooks on the sympodite of the pleopods could be interpreted as a modification (within the Phreatoicoidea) of the entangling setae,[1] but since similar coupling hooks are found on the pleopods of many Amphipoda, Cumacea, and Tanaioidea as well as in many of the other sub-orders of the Isopoda, these, too, are probably correctly interpreted as representing the retention of a once general Peracaridan feature and their absence regarded as a specialization due to loss. Possibly the ancestral Phreatoicid had both coupling hooks and setae. This suggestion is supported by the fact that coupling hooks may arise directly from the sympodite, whereas entangling setae are nearly always carried on strongly-developed outgrowths (coupling lobes) of the sympodite—a consequence of the mode of functioning of these setae which seems to require them to spring practically vertically from an outstanding lobe; were the coupling hooks a secondary acquisition, independently arising within the sub-order, the lobes might have been expected to have been retained more completely. If, as suggested earlier, these coupling lobes are remnants of gnathobasic outgrowths, once present on all appendages, there may have been a regression of these structures, more noticeable in those genera that retain coupling hooks than in those that link the pleopods by entangling setae only.

15. The Penial Stylet

The penial stylet, too, is found in two widely different forms; that characteristic of most of the Amphisopine forms is stout, strongly curved, tapering to a point and devoid of terminal spines; the alternative condition is that of a simple, incomplete, cylindrical tube with a terminal fringe of stout spines (with, in some cases, a sub-terminal series as well). This latter prevails throughout the Phreatoicidae, but is seen in its simplest form in one Amphisopine genus *(Mesamphisopus)*

[1] Just as setae have been modified and developed into coupling hooks on the maxilliped.

and a little modified in *Hyperoedesipus*. In *Hypsimetopus* and *Phreatoicoides* there are modifications of the Amphisopine condition. In this stylet we have, apparently, something new developed within the Isopoda, with no counterpart amongst Mysids, Syncarids, Amphipoda, or Tanaioidea.

16. Tailpiece

The condition of the tailpiece, or rather the telsonic apex of that region, again provides an interesting problem. Is the condition seen in *M. tasmaniae* (so reminiscent of the telsonic spine of *Acanthotelson*) a primitive or a secondary feature? In many of its characters, *tasmaniae* is linked with the more specialized (presumably more modern) Phreatoicidae, while yet retaining some distinctive primitive features. In those forms in which there is the greatest aggregation of primitive features, the telsonic projection is minute or absent.

17. Dorsal Flange on Uropod

Another interesting, but variable, feature is the development of a thin dorsal flange along the inner border of the peduncle of the uropod. In almost every species, the distal mesial angle, at least, is strongly produced, being armed with a couple of particularly stout spines. In two or three genera, included here as among the more primitive, this mesial process may be found greatly enlarged at its maximum development, giving to the uropods the appearance of possessing a third ramus as stout as the two normally present.

A comparable development of the peduncle is found in at least one other Isopod group, the Cymothoidea,[1] the retention of this character in some Phreatoicids providing further support for the suggestion of the origin of this sub-order from a very generalized form near the base of the Isopodan series.

18. Uropodal Rami

The occurrence, in some Amphisopine genera, of bluntly truncated uropodal rami with a terminal, stout, freely movable spine, suggests the possibility that there is represented here a two-jointed ramus,[2] in which case the sharply-pointed apex to the rami in the Phreatoicine forms is to be regarded as the product of fusion of these parts, i.e., the final *loss of freedom* of the terminal joint.

Hyperoedesipus seems to show a stage in which this loss of freedom is already accomplished in the inner ramus, but the outer ramus, which is stout, narrows abruptly at the transition into the terminal spine, as though the incorporation of the terminal piece had not been well established. There has been found nothing in support of the alternative view that the freedom of this terminal joint has resulted from the development in the Amphisopinae of an articulation here; the condition found in *Eophreatoicus*, *Mesamphisopus*, *Amphisopus*, etc., must presumably be regarded as that once general for the sub-order.

19. Typhlosole

A typhlosole, of variable extent, is found in the great majority of genera. The figure given by G. Smith is accurate for *Phreatoicopsis*, and this condition is closely approached in *Synamphisopus*. In most forms, however, the fold is more

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(1) Cirolanidae (Cirolana, Exocorallana, Rocinela, etc.). In some Idotheoidea (e.g. *Austridotea*) it is perhaps represented by the single mesial spine.

(2) The fact that in Mysids, Tanaioidea, numerous Amphipods and many other Isopods, the uropodal rami are two or many-jointed supports the view that in the Amphisopidae there is retained the last trace in the Phreatoicoidea of the more primitive multi-articulate uropod.

simple, recalling the condition existing in many Earthworms, excepting that it is ventral, instead of dorsal, in position. Barnard (1927, pp. 144-5), who questions the accuracy of Smith's statement, apparently had for examination no specimen of *Phreatoicopsis* and was unlucky in that *Mesamphisopus*, of which he had abundant material, is one of the few Phreatoicids lacking a recognizable typhlosole. While it is possible that this structure is a development peculiar to this sub-order, some of the least specialized Oniscoidea seem to have it in a reduced (or perhaps rudimentary) condition (e.g., *Ligia*, Hewett, pl. 2, fig. 16).

20. Quasi-hermaphrodite

The quasi-hermaphrodite state may be considered either as a primitive condition persisting in a few forms or as a variably developing new condition; its known distribution in the sub-order points to the former.[1] There is no information available concerning the condition of the internal organs, and, as suggested above, the repetition of coxal outgrowths along the series of peraeon appendages may have been originally unrelated to sex.

21. Comparative Sizes of Body Parts

One other matter may perhaps be most conveniently considered here. It concerns the comparative lengths of the several regions of the body and also of individual body segments. The comparative length of the different regions of the body, as well as of individual segments, is generally regarded as having a considerable importance for systematic purposes. From several causes, however, measurements made from preserved material may yield discrepant results. In the first place, there can be a notable variation in the degree of extension of the intersegmental rings in the peraeon, but, in addition, the degree of exposure (or concealment) of the segments themselves may, likewise, vary considerably. The *posterior* border of the head and the *anterior* border of the second to seventh peraeon segments may consist of an incomplete hoop of scarcely calcified chitin which is thinner and lies at a level somewhat below that of the general surface of the rest of the segmental ring. In the South African species, particularly, these bevelled articular borders are well developed and may be exposed to a variable extent, or, under-riding the next adjacent tergum, may be completely hidden. Of the peraeon segments, the first alone lacks this smooth bevelled border. It may over-ride both the head and the second peraeon segment to a quite variable extent, or it may be found quite separate from one or both by a more or less considerable intersegmental gap, or, in other species, wholly fused with the head. In any case, the first peraeon segment, alone, must always display its full length, whereas in the succeeding segments, the whole or part of the free (under-riding) anterior margin may be exposed or hidden from view. It will be obvious, then, that the length of the head and of the second to seventh peraeon segments will individually be liable to underestimation. On the other hand, the combined length of head and peraeon may be, quite appreciably, either over- or under-estimated.

In the pleon, intersegmental gaps are rarely found, but a certain amount of telescoping of these pleon rings may nevertheless occur, when the body is straightened, or there may be brought about the maximum extension dorsally when the pleon is downturned and carried more or less beneath the body. In these circumstances, the visible length of pleon segments (particularly the fifth

[1] A functional hermaphroditism is said to occur in another generalized Isopod sub-order—the Cymothoidea.

and sixth) may vary quite markedly. Accordingly, *in the fully contracted state*, the total length of head and peraeon is quite considerably less than the total length of the constituent parts, and comparisons made by different authors concerning the relative length of different regions may afford quite conflicting results. For purpose of comparison, therefore, measurements of regions should be made, if possible, on specimens which are sufficiently relaxed to show the whole of the body rings but not to display the uncalcified intersegmental membrane. In measuring the length of the head, the horizontal distance between two verticals drawn from the anterior border of the ocular lobe and the hinder articular margin respectively should be taken and should include the (posterior) under-riding articular border.

SYSTEMATIC

Order **Isopoda**

Peracarida without distinct overhanging carapace, although both first and second thoracic somites may be united with head. Body generally strongly flattened dorsi-ventrally (except Phreatoicoidea); telson usually united with last somite. Antennules uniramous (except in *Bathynomus*), antennae rarely with minute exopodites; thoracic limbs without exopodites; first pair (maxillipedes), with epipodites, not enclosed in branchial cavity but which, when well developed, may replace functionally the overhang of carapace; seven remaining pairs, all similar or variously modified, coxae always short, often fused with body and expanded laterally, ischia *relatively long*. Pleopoda typically biramous with lamellar branchial (sometimes natatory) rami, the second pair, and sometimes the first also, modified in the male. Heart lying wholly or in part in the abdomen; the young leave the brood-pouch before the appearance of the last pair of thoracic limbs. Some may be hermaphrodite.

The probable position of the sub-order Phreatoicoidea within the group is, in the opinion of the present writer, indicated by the following

Key to the Sub-Orders of Isopoda[1]

A. Uropoda lateral—
  C. Body sub-cylindrical, fusiform; pleon appearing compressed. Uropoda ambulatory; pleopods natatory and respiratory .... *Phreatoicoidea*
  D. Body depressed, (semi-cylindrical):
    E. Uropoda forming, with tailpiece, a caudal fan; pleopods natatory and respiratory .... *Cymothoidea*
    F. Uropoda valve-like, inflexed, meeting beneath pleopoda which are largely branchial .... *Idoteoidea*
B. Uropoda terminal, body depressed—
  G. Pleopoda exclusively branchial:
    J. First pair generally modified into a thin opercular plate .... *Aselloidea*
    K. Pleopoda never covered by opercular plate. Parasitic forms .... *Bopyroidea*
  H. Pleopoda adapted for air breathing .... *Oniscoidea*

Sub-order PHREATOICOIDEA

Body sub-cylindrical and fusiform, the pleon appearing compressed chiefly on account of the strong downward development of the pleura; the first thoracic segment generally ill-defined and always forming part of the head, the second thoracic (first peraeon) segment may be free or fused with the head. Eyes large, small

[1] This is a modification of the key published by Richardson (1905, p. 3).

or absent; when present may be widely separated or relatively near to each other. Antennules and antennae unequal in length, a peduncle usually clearly marked off from a flagellum, exopodite invariably wanting. Mouth parts primitive, upper lip asymmetrical, the freely movable labrum depending from a stout interantennal plate (epistome); mandibles have a three-jointed palp, a 'pars incisiva', a lacinia mobilis (which may be present on both mandibles or on left mandible only), spine-row and molar. The spine-row is, in some, separated from molar by a row of free setae and is itself mounted on a raised elongate base. Maxillula, proximal endite with many (nine or ten) to few (two or three) terminal setospines; median process may be present immediately in front of maxilliped (cf. Cumacea); maxilliped well developed, coxa with epipodite, and, in mature females, with vestige of oostegite, outer distal angle of basis with strong plumose spine, palp long, five-jointed.

Peraeon with six or seven free segments, the seven pairs of peraeopods being divided into an anterior group of four, directed forwardly, and a hinder group of three generally turned backwardly. Of these, the first pair is always prehensile (sub-chelate), the second, third and fourth are ambulatory and rarely prehensile (except in the male, the fourth, which is very generally sexually modified), the last three pairs ambulatory and capable of being raised over the back as in Amphipoda. The incubatory pouch consists normally of four pairs of brood lamellae, but there may be vestiges of two other pairs, one more anterior (maxilliped) and one posterior (fifth peraeopod). The penes are usually long and arise, widely separated, from the coxae of the seventh peraeopods. Pleon generally long, with six distinct segments, fifth always longest (cf. Cumacea), sixth firmly united with telson. Pleopods well developed, adapted for both swimming and breathing; the exopodite, in all but the first, with two distinct joints; second pair, modified in the male, with a penial stylet arising from the mesial border of the endopodite; the hindmost three (or four) pairs bear a free epipodite.[1] Suture between sixth pleon segment and telson more or less strongly developed. The uropoda are lateral and biramous and are used in locomotion; the peduncle may be strongly produced into a disto-mesial process.

The sub-order contains but two families, distinguished by the condition of the mandible:

I. *Family Amphisopidae.*
Both mandibles with lacinia mobilis.

II. *Family Phreatoicidae.*
Only the left mandible retains lacinia mobilis.

Family **Amphisopidae**

Body sub-cylindrical, or sub-depressed, appearing compressed;[2] head relatively short, its posterior border usually overlapped by a short first peraeon segment. Eyes, when present, prominent and many facetted. Peraeon segments deeper than long; pleon segments deep. Telson not, or scarcely, produced into terminal projection. Both mandibles with pars incisiva and lacinia mobilis. Maxillula with numerous setospines on apex of proximal endite; coxae of peraeopods generally fused with pleura, basis of hinder peraeopoda usually well-expanded.

All known members of the sub-order are aquatic and in general are restricted to cold fresh water, but some members of this family are unusual. *Phreatomerus latipes* seems to be able to thrive in the steaming hot water issuing from deep artesian bores, while *Phreatoicopsis terricola* is stated to live in shallow burrows. Neither Spencer and Hall nor Raff has made any reference to the habits of this

(1) Except two subterranean genera. (2) Except *Phreatomerus.*

latter animal, but it has been found that specimens kept under observation over several months in the laboratory would frequently come to the surface and creep over the surface of the wet soil. They appear to be strongly photophobic (their eyes apparently becoming luminous when strongly lighted) and probably under natural conditions leave their burrows only at dusk, presumably to feed. They are probably gregarious and when newly taken are often heavily infested with *Temnocephala*. *Mesamphisopus* spp. alone are certainly known to be capable of aestivation, tiding over summer aridity buried in the muddy floor of dried water holes; it is probable that *Paramphisopus* spp. may also occasionally pass through a dormant period.

Members of this family range from tropical North Australia to the temperate South-West, from the Central arid area to regions where conditions approach subalpine in South Africa, Victoria, and Tasmania. A blind and wholly subterranean species occurs in the Darling Range of West Australia, and semi-terrestrial burrowing forms in the Grampians and the wet Beech Forest of the Otways and the still wetter West Coast region of Tasmania.

With so wide a range and a marked diversity of habitat, it is scarcely surprising that a satisfactory diagnosis, which shall embrace them all, is not easy to formulate, nor that many members transgress its limits in one particular or another.

Analytical Key to Genera of Family Amphisopidae (except Protamphisopus)

A. Pleopods with coupling hooks.
  B. Antennule short; second pleopod modified in the ♂; penial stylet short and cylindrical, armed terminally.
    C. Eyes prominent, uropod with simple spine on peduncle beneath rami; terminal spines on rami movable .... *Mesamphisopus*
    C¹. Eyes absent; a group of short, toothed terminal spines beneath rami of uropods, terminal spine on rami fixed .... *Hyperoedesipus*
  B¹. Antennule long, filiform; eyes large, prominent; both first and second pleopods modified in male; penial stylet large, tapering, unarmed; terminal spine on rami of uropods movable.
    C. Body subcylindrical, basis expanded only on hinder peraeopoda.
      D. Telson convex terminally. Spine beneath rami of uropod simple; fourth peraeopod not sexually modified .... *Paramphisopus*
      D¹. Telson emarginate. Spine beneath rami of uropod toothed; fourth peraeopod sexually modified .... *Amphisopus*
    C¹. Body depressed; basis, ischium, merus expanded on all peraeopods; terminal spine beneath rami of uropods simple; telson incised .... *Phreatomerus*
A¹. Pleopods without coupling hooks.
  B. Eyes present.
    C. Eyes prominent, large; penial stylet long, cylindrical, armed terminally; basis ischium and merus expanded on all peraeopods, spine beneath rami of uropods simple; terminal spine on rami movable .... *Eophreatoicus*
    C¹. Eyes small, typhlosole well developed; strong disto-mesial process on peduncle of uropod.
      D. Typhlosole a double scroll-like structure, penial stylet large, tapering, unarmed
        E. Hinder peraeopods with bases strongly expanded, spine beneath insertion of rami of uropods toothed, terminal spine on rami movable .... *Synamphisopus*
        E¹. Hinder peraeopods with basis almost cylindrical, spine beneath insertion of rami of uropod stout, simple; terminal spine on rami fused, immovable .... *Phreatoicopsis*
      D¹. Typhlosole, circular in section, penial stylet long, cylindrical, armed; hinder peraeopods with basis moderately expanded, spine beneath insertion of rami of uropods toothed, terminal spines on rami fixed immovable .... *Uramphisopus*

B¹. Eyes wanting, penial stylet short, tapering, unarmed.
C. First pleopod with plumose setae on both lamellae, epipodite on last three pleopods .... *Hypsimetopus*
C¹. Plumose setae absent from endopodites of pleopods and rare or absent from outer lamella; epipodites wanting .... *Phreatoicoides*

Twelve genera are recognized, five of which are new.

Until 1926 all but four of the known Phreatoicids had been assigned to the genus *Phreatoicus*, which constituted a very mixed assemblage. In that year three species, *latipes* Chilton, *palustris* Glauert, and *lintoni* Nicholls were removed and placed by the present writer in a new genus *Amphisopus*; in the following year Sheppard suggested the name *Phreatomerus* for the same three species. A much more thorough study of these species has, however, provided evidence of the essential distinctness of each and warrants their further separation to distinct genera.

The type species *A. lintoni* has revealed several unsuspected points of resemblance to the *Phreatoicinae*, features which are not shared by *latipes* and *palustris*. Of these three, therefore, *lintoni* can alone be retained in the genus *Amphisopus*, but with it is now associated a second and new Western Australian species '*annectens*'.

The species described by Chilton under the name *P. latipes* had been chosen by Miss Sheppard as the type of her new genus *Phreatomerus*, and, since it is no longer to be included in *Amphisopus*, should be known as *Phreatomerus latipes* (Chilton). It appears to stand more apart, perhaps, than any other Phreatoicid; its nearest affinity seems to be with *Phreatoicopsis*, and, to a rather less degree, with the West Australian species *Paramphisopus palustris* (Glauert). But, alone amongst the Phreatoicids, it exhibits conspicuously a condition that can be justly described as 'depressed' (actually all the other Amphisopine forms are subdepressed). There can, however, be little question but that this is a condition derived altogether independently from that of other Isopodan orders.

P. palustris (Glauert) occupies a less extreme position than *P. latipes*, and has its closest affinities with *Amphisopus*, but possesses several characters linking it with the South African species. For its reception is proposed the genus *Paramphisopus* and with it is included a second, small West Australian form from the Darling Range, here described under the specific name *montanus*.

For a species taken from a pool in the creek beneath 'Fish Falls' in the Victorian Grampians, there is instituted a new genus *Synamphisopus*, almost intermediate between *Amphisopus* and *Phreatoicopsis*, but showing affinities, also, with the New Zealand and South African forms. It is represented only by a single species which had been named, in manuscript, after its discoverer, Dr. Tillyard, who took it in 1929. The publication of the description of this (and other new species) was withheld until this present paper should be complete, but in the meantime the species was recorded by Sheard (1936) under the name *Amphisopus ambiguus*. It is of interest that from this same region a semi-terrestrial form had already been recorded (Raff, 1912) and assigned to *Phreatoicopsis terricola* with which this freshwater species has very much in common, and to which—the largest of living Phreatoicids—it approximates, also, most nearly in size.

The South African species were, by Miss Sheppard's definition of *Phreatoicus* Chilton, clearly excluded from that genus, since, as Barnard (1914, p. 236) had noted, all the coxae are fused with the pleura of their respective segments, whereas Miss Sheppard defines *Phreatoicus* as having the second to seventh coxae free.

Actually, however, the African forms are, not only in this but in almost every other respect, Amphisopine rather than Phreatoicine. For *P. capensis* Barnard and its two allied forms, *abbreviatus* and *depressus* (which are here raised to the rank of species) is now proposed the new generic name *Mesamphisopus*.

The necessity for the institution of a new genus *(Protamphisopus)* for the Triassic fossil species is discussed at a later stage, but there can be little doubt that the species *wianamattensis* would have been recorded as of the Amphisopine type (had that then been recognized) rather than as 'similar in general appearance to *P. australis*'.

A species from the Great Lake, Tasmania (probably a burrower) approaches *Phreatoicopsis* and *Synamphisopus*, and is included under the name *Uramphisopus pearsoni*.

Another Amphisopine genus is the monotypic *Hyperoedesipus*. This, notwithstanding Miss Sheppard's judgment that it must be regarded merely as synonymous with *Phreatoicoides*, likewise proves, when re-examined, to be in nearly all particulars Amphisopine. It is undoubtedly phyletically distinct from *Phreatoicoides* and will retain, therefore, its original generic designation, for, as is shown in the sequel, it owes most of its resemblance to that genus simply to parallel modifications in adaptation to a similar (subterranean and aquatic) mode of life. The study of a second species of *Phreatoicoides* found in the isolated ranges of Western Tasmania, and a third from the Otway Forest has established the fact that characters dismissed by Miss Sheppard as trivial actually have generic significance.

Hypsimetopus may be Amphisopine. Its description is, however, not very complete, many important characters not having been mentioned by Sayce. Since but a single specimen, beside the type, remains in the Collection of the Melbourne Museum and permission to dissect this was denied, the position of this genus must remain somewhat uncertain,[1] but it seems probable that it may be the link between *Phreatoicoides* and the Phreatoicopsine forms.

In *Phreatoicoides* we have several resemblances to *Hyperoedesipus*, but, as noted above, these seem to be the result of convergent evolution and not evidence of near relationship; in any case, reduction has gone much further in *Phreatoicoides* than in any other Phreatoicid. Certain of its features suggest, however, a kinship with *Hypsimetopus*, which is, only after considerable hesitation, here assigned to this family; as a consequence, the genus *Phreatoicoides*, which seems to have been derived from it, is also placed in the Amphisopidae.

As suggested by the key, these genera fall into four groups for each of which the rank of sub-family is suggested. If *Phreatoicoides* and *Hysimetopus* are included in the Amphisopidae they would constitute a fifth sub-family.

The family Amphisopidae, therefore, has been sub-divided as follows:—

Sub-family I.—MESAMPHISOPINAE
- Genus—*Mesamphisopus*
- Genus—*Hyperoedesipus*

Sub-family II.—AMPHISOPINAE
- Genus—*Paramphisopus*
- Genus—*Amphisopus*

Sub-family III.—PHREATOMERINAE
- Genus—*Phreatomerus*

Sub-family IV.—PHREATOICOPSINAE
- Genus—*Synamphisopus*
- Genus—*Eophreatoicus*
- Genus—*Protamphisopus*
- Genus—*Phreatoicopsis*
- Genus—*Uramphisopus*

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[1] Three protracted but unsuccessful attempts have been made (in 1928, 1929, and 1939) to re-discover this species.

Sub-family V.—HYPSIMETOPINAE
Genus—*Hypsimetopus*
Genus—*Phreatoicoides*

Sub-family I. MESAMPHISOPINAE

Small forms, sub-alpine or subterranean; body sub-depressed and scaly, in *Hyperoedesipus* vermiform; head with well-marked cervical groove; eyes either small, but prominent, with few ocelli, or absent; first peraeon segment free, telsonic apex scarcely produced. Antennule short; antenna long; mandible forwardly placed; coxae of peraeopods fused with their related segments; bases of hinder peraeopods little expanded; vestige of oostegites on fifth peraeon segment. Fourth peraeopod slightly sexually modified. All pleopods with plumose setae, sympodites with entangling setae and, in the first three pleopods at least, with coupling hooks as well; penial stylet incompletely free from lamella of endopodite, armed with terminal setae; rami of uropods lamellar, the ends truncated and armed with stout, movable spines (except *Hyperoedesipus*). Brood-pouch with relatively few embryos.

The inclusion of the eyeless and specialized subterranean *Hyperoedesipus* deprives this definition of some of its precision. The retention in all the pleopods of *Mesamphisopus* of an endopodite bearing plumose setae is highly distinctive, but this feature is lost in *Hyperoedesipus*, although that form is unique among subterranean species in preserving a primitive, heavily plumose, condition of its exopodite; *Mesamphisopus*, too, retains the free terminal spines (or second joints) on the uropodal rami, whereas in *Hyperoedesipus* fusion, complete or partial, has already taken place at this point. The occurrence of the more typical Amphisopine feature of a large simple spine at the end of the peduncle of the uropod in *Mesamphisopus* is not a characteristic of *Hyperoedesipus*.

Mesamphisopus, gen. n.

Body robust, markedly scaly; sub-depressed (sub-cylindrical), fusiform, length less than six times greatest breadth. Head short, with sub-ocular incisure, with a well-developed cervical groove rising from the ventro-lateral border, with a posterior process behind mandible; eyes moderately prominent, though small and with few ocelli. Peraeon much wider than deep; first peraeon segment free from head; pleon relatively long; pleura well developed; tailpiece tapers uniformly to a short projection which has a small flattened postero-ventral surface, and is armed with three pairs of movable spines, with one stout, sub-marginal spine laterally on the telsonic pleuron.

Antennule short, flagellum with few joints; antenna long. Both mandibles bear a lacinia mobilis; maxillulae with numerous (up to six) setospines on apex of proximal endite. Gnathopod not particularly strong, with an oblique palm extending practically along entire posterior border of propod, dactyl moderately long with denticulate inner border. The modification of fourth peraeopod in the male seems to involve the last three joints; brood lamellae are developed on first to fifth peraeon segments. The first three pairs, at least, of the pleopods are furnished with coupling hooks, endopodites of all the pleopods retaining a partial fringe of plumose setae; penial stylet of male curved only at its apex and but partly free from the related endopodite, with well-developed armature of stout setae. In the uropod the peduncle is short, produced at inner distal end and with simple terminal spine, inner ramus long, both rami with terminal spines freely movable. Three species known.

Genotype. *Mesamphisopus capensis* (Barnard).

Like *Synamphisopus*, this genus occupies a nearly central position within the sub-order. In many of its characters, it is Amphisopine, but in others (some of which are probably primitive) it shows affinity with the Phreatoicidae. The smallness of the eye, with few ocelli, is probably without phyletic significance, reduction of the eye having seemingly occurred many times in the Phreatoicoidea.

In the retention of a fifth pair of brood lamella, *Mesamphisopus* and *Hyperoedesipus* are peculiar in this sub-order but in that oostegites are borne on the fifth peraeon segment, it resembles the condition in the *Apseudidae* and some *Cymothoidea* and *Oniscoidea*. In both *capensis* and *abbreviatus* the fifth pair of lamellae, though free, are small and probably not functional; the oviduct appears to open just internal to its base. In *Hyperoedesipus*, it is still smaller and in *Synamphisopus*, the lamella persists only as a flattened plate firmly adherent to its related sternite and the oviduct apparently perforates it. In other genera, it seems to have disappeared entirely. In the possession of plumose setae upon the endopodite of the pleopods, it is most nearly approached by the surface-living New Zealand forms and again recalls the condition of the *Apseudidae*; but it is more primitive than in any other living Phreatoicid, since the setose (natatory) condition of this lamella is retained on all five pleopods; in *Notamphisopus* and *Hypsimetopus* only the first pleopod retains this condition, and in those genera the coupling hooks are wanting.

In the peculiar modification of the fourth peraeopod in the male, *Mesamphisopus* seems most nearly to resemble *Amphisopus* and *Eophreatoicus*. The markedly scaly condition of the surface of the body is seen in *Eophreatoicus* and *Phreatoicopsis* and in a lesser degree in *Amphisopus*, *Synamphisopus*, and *M. tasmaniae*. Coupling hooks on the pleopods are restricted to the *Amphisopinae* and *Mesamphisopinae*.

The retention, in some species of this genus, of numerous setospines on the apex of the proximal endite of the maxillula is an Amphisopine character, this condition being found in *Amphisopus*, *Paramphisopus*, *Phreatomerus*, *Eophreatoicus*, *Phreatoicopsis*, and, also, in *Phreatoicus* (s.s.);[1] and the retention of a *lacinia mobilis* on right as well as on left mandible characterizes all of those forms, with the exception of *P. typicus*.

The bluntly-ending rami of the uropods with their terminal armature of one, or more, freely movable spines is again a feature characteristic of the Amphisopinae, persisting otherwise only in *Eophreatoicus* and *Synamphisopus*. The simple (non-toothed) condition of the terminal spine on the peduncle, at the base of the rami, recurs in the genera *Paramphisopus*, *Phreatomerus*, *Eophreatoicus*, *Phreatoicopsis*, and *Phreatoicus* (s.s.). On the other hand, the cylindrical penial stylet of *Mesamphisopus* has a strong resemblance to the condition found in *Hyperoedesipus*, *Eophreatoicus*, and, in a lesser degree, in *Notamphisopus*. In both *Mesamphisopus* and *Hyperoedesipus*, the actual stylet is short and its base long, and the terminal armature reduced; whereas in *Eophreatoicus* it is the base that is short and the freely movable stylet long, and the terminal armature complete, but otherwise the structures are closely comparable and differ from that of other Phreatoicids.

But the retention on the head of a well-developed cervical groove, of a short club-shaped antennule with few joints, and, in the peraeon, of the freedom of the first segment, are features shared with *Hyperoedesipus*, but characteristic of the *Phreatoicidae*.

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[1] And as a rare variation in *Notamphisopus* and *Mesacanthotelson*.

Mesamphisopus capensis (Barnard)

(Figs 6, 7)

Barnard, 1914, p. 223, pls. 23 and 24; 1927, p. 139, figs 1, 3-6 *(Phreatoicus capensis).*
Sheppard, 1926, p. 109 *(Phreatoicus capensis).*

The original description published by Barnard appeared at a time when there were known but few Phreatoicids, all from South-Eastern Australasia and New Zealand. The account was somewhat brief, comparison was made principally with *P. australis*, and attention was not drawn to several characters which subsequent work has shown to have significance. Later, Miss Sheppard in her 'Revision of the Phreatoicidae' dealt with the South African species somewhat superficially. Although specimens were available for study, her account adds nothing to our knowledge and seems merely an inadequate summary of Barnard's description, some of the omissions being unfortunate. Moreover, in view of the importance that Miss Sheppard attached to the fusion or freedom of the coxa of the peraeopods, one, at least, seems inexplicable, for in the 'Revision', the free condition of the hinder six of the coxae is made a generic character for *Phreatoicus*. Barnard had stated quite positively (1914, p. 236) that the coxae of all the peraeopods were fused with their related segments ('epimera'). Yet, without comment, *capensis* is included in that genus, although there can be little doubt that Barnard's statement is substantially correct.(1)

In addition to supplying, generously, preserved material of the three South African species, Dr. Barnard went to considerable trouble to provide abundant living material of *capensis*, when the writer was passing through Cape Town in Mid-winter, 1936. With constant attention these survived the voyage to West Australia and lived under laboratory conditions until the end of the year, but in January, 1937, after a short absence from Perth, all were found to have died. Just a year later, Dr. Barnard sent another consignment, but unhappily these succumbed on the journey. For all of this help grateful acknowledgment is made.

A number of observations had been made, however, upon the fresh material and a very detailed study confirmed the view that *capensis* was not, as Barnard believed (1927, pp. 155 and 158), most nearly related to *australis*, but was, indeed, generically distinct and to be classed, on the sum-total of its characters, with the Amphisopine rather than the Phreatoicine members of the sub-order. This view had been put forward earlier (in 1926), but the summary (published in 1928) omits the analysis on which this conclusion was based. There seems little room for doubt that *capensis* retains a large number of primitive features and thus shows affinities with several different, and to-day, widely scattered, groups of Phreatoicids. A satisfactory discussion of this matter is possible, however, only in the light of a much fuller description.

Body stout, sub-depressed, length less than six times the greatest width. In the peraeon, the width is little less than twice the depth, so that a transverse section through this region is markedly different from that of some Phreatoicine forms, but even so, the flattening is much less extreme than that found in the Amphisopine form, *Phreatomerus latipes*. Sculpturing of the head and peraeon is scarcely developed, but the surface, examined under a fairly high magnification, is marked in such a way as to suggest a covering of closely adherent and but slightly overlapping scales, the free edge of each scale being produced into a short fringe of stiff setules. There are, also, short and sparsely scattered setae

(1) There may be a slight mobility in the three hindmost coxae.

The *head* (fig. 6, *2d*, *2s*) is as deep as wide, and rather wider than long, its length being less than the combined length of the first and second peraeon segments; its anterior border is emarginate but bulges immediately in front of the eyes. From the sub-ocular incisure, the front slopes upward, the slope being much less

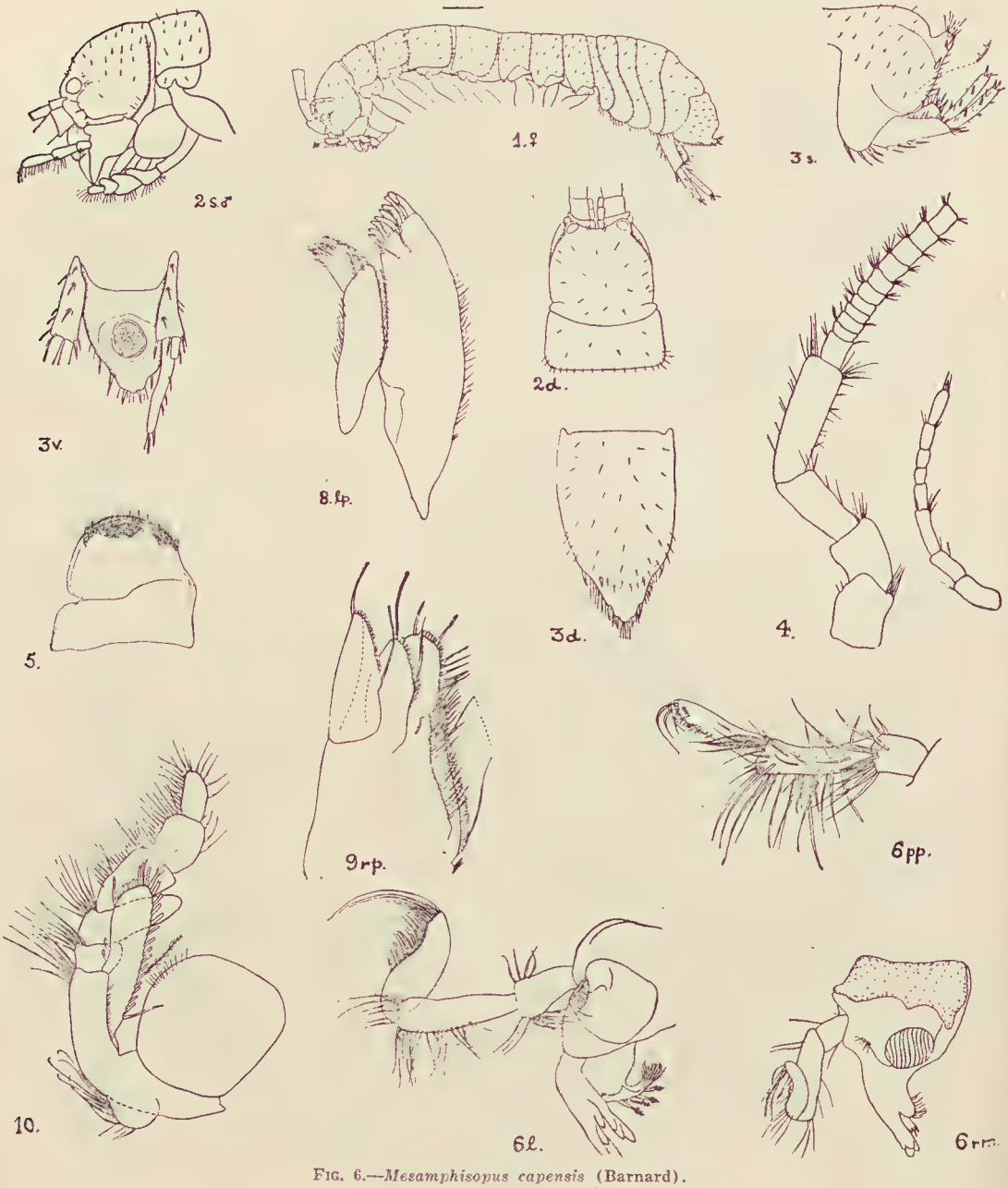

FIG. 6.—*Mesamphisopus capensis* (Barnard).

steep in the male. Starting from behind the eye, there is a well-marked genal groove, but, below the incisure, the sub-ocular segment is not well defined. The ventro-lateral border of the head makes a very uneven line with the mandibular articulation (fig. 6, *2s*) and is produced downwardly behind the mandible into a short ' posterior process '. The cervical groove is well marked and springs from the ventral border demarcating a maxilliped segment which is incomplete dorsally but unusually wide below. The hinder edge of the groove is raised into a distinct ridge, behind which the postero-lateral surface of the head is partly exposed.

The *peraeon.* The first segment is long, practically half the length of the head and is slightly shorter than the second, and is unusual in that it is not shortest in the mid-dorsal line. There would seem to be considerable variation here, for Barnard notes that the second, third, and fourth segments are sub-equal and ' *nearly as long as* ' the first. In the specimens examined, the third and fourth segments appear to be a little longer than any of the others, the terga only about as deep as long, the ventral (sternal) region not being hidden, in side view, in the male; in the female, these segments are, relatively, a little deeper; the fifth and sixth segments are sub-equal, the seventh considerably shorter and deeper, its depth almost twice its length; the first segment is scarcely forwardly produced, while the second to seventh are all downwardly produced in front of the related coxa, and the ventro-posterior corners are rounded. The hinder borders of the peraeon segments are fringed with short setae.

The length of the *pleon* appears to vary considerably as compared with that of cephalo-peraeon, according to the state of contraction of the latter. It differs from most other species in the abruptness of its deepening, the first pleon segment being once and a half as deep as the last peraeon segment and nearly twice and a half as deep as the second peraeon segment. The second, third, and fourth show the usual progressive increase in length but little greater depth, while the fifth is equal to the combined length of the third and fourth and rather longer than the tailpiece. In all of the five pleon segments, the rounded lower margins are armed with long setae, this fringe being continued up the posterior margin of the pleura for some distance. The fifth pleuron meets its segment behind in a deep rounded notch.

The tailpiece (fig. 6, *3*) is helmet-like in side view; seen from above, it appears as a truncated cone; from below it is, as figured by Barnard, more nearly sub-triangular, the terminal projection being strongly marked off from the rest of the piece. In profile the telson is strongly convex, but its dorsal surface is distinctly concave just anterior to the slightly uptilted apex. The telsonic pleura, confluent with the apex, bear three pairs of freely movable spines, the last pair lateral and terminal. Below, there are slender widely-spaced setae. Only a short suture indicates the junction of telson and sixth pleon segment, this being unarmed, except for a row of microscopic spinules (cf. *Eophreatoicus*).

Anterior to the uropod, the pleuron of the sixth segment is narrow, its anterior border straight and nearly vertical, its lower rounded margin bearing but three of four spines,[1] the last exceptionally stout. The anal opening is presented ventrally.

The *antennule* agrees quite closely with Barnard's description, except that there may be variation, in the flagellum, from three or more longish joints to six shorter ones, with the last usually minute, the fourth and fifth sub-equal and the first longer than the second or third. These are probably differences due to growth,

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[1] The comparative paucity of spines in this region is paralleled in *Eophreatoicus, Amphisopus,* and some New Zealand species.

but the appendage differs notably from both *abbreviatus* and *depressus* in the slenderness of the peduncle of this appendage. There is normally a terminal tuft of olfactory cylinders.

The *antenna*, too, shows slight variation from the description given by Barnard (for the male), the second and third joints of peduncle being practically sub-equal, the entire appendage rather more than half the length of the body. In the female, the flagellum is about twice the length of the peduncle and has approximately twenty joints. It is noticeably long and slender as compared with those of *abbreviatus* and *depressus*.

Both the *labrum* (fig. 6, *5*) and epistome show to a very marked degree the asymmetry which characterizes this region in this family.

Mandibles. These (fig. 6, *6*) are stout; they articulate by a long, uneven hinge with the ventro-lateral border of the head, the hinder end abutting against the antero-ventral part of the maxilliped segment but not, apparently, developing the usual hollow acetabular surface; there is present an unusually extensive opening mesially for the adductor muscle. At the anterior end, the large fulcral process is almost conical and moves upon the sub-ocular lobe and against the outer border of the upper lip. On the right side, the mandible seems rather shorter and stouter than the left, there appears to be a trace of a fourth tooth on the cutting edge, the lacinia mobilis is much slighter, the spine row smaller, differently-shaped, and with a number of free setae springing from its shaft; the molars exhibit the usual difference in shape and disposition, the palp seems rather less setose.[1] In the left mandible the tooth-bearing part is long and strongly bent, ending in four stout teeth; the lacinia mobilis is, also, strong and bears but three heavily chitinised teeth. The spine row is raised on a high base and the spines, well separated distally, are closer and more slender as the free end is neared. The palp (fig. 6, *6l*, *6pp*) is well developed and has a moderately long first joint with a number of long setae sub-terminally, the second joint nearly twice as long with a fringe of long setae extending almost the entire length of its anterior border and a terminal circlet, while the third, little shorter than the second, has the characteristic (sub-crescentic) shape, with fine setae along most of its concave edge. The apical setae being increasingly long, the terminal setae are simple and as long as the joint itself.

The *lower lip* calls for little comment. It resembles that of *Amphisopus* rather than *Phreatoicus* and among its terminal setae appear to be some setospines.

The *maxillula* (fig. 6, *8lp*) appears to differ rather markedly from the condition figured by Barnard (1917, pl. 23, fig. mx. 1.) where the two endites are shown almost equally wide. In the several specimens examined, the inner (proximal) endite is much smaller than the outer; its apex is obliquely truncated rather than rounded and the setospines, four or five in number, are rather widely separated, the innermost rising from the mesial border of the endite. They are flanked by a parallel row of three,[2] which are feebly ciliated. The outer (distal) endite is stouter, longer, slightly bent, and narrowed distally. It bears the usual double, partly triple, row of denticulate spines (12-14). Upon its posterior face, there are two feathered setae.

The *maxilla* (fig. 6, *9rp.*) is relatively short and wide. Its proximal endite is clearly marked into two regions; (i) a proximal-mesial with the typical anterior row of filtratory setae backed by the posterior (sub-marginal) rank of stiff pectinate

(1) In the armature of the mandibular palp, this species recalls the condition found in some species of *Mysis* and *Apseudes*.

(2) Sometimes only two, but four in one specimen.

setae; and (ii) the distal part meeting the proximal at a sharp angle, the junction, in some cases, seeming to be marked by a short cleft. It is armed with the characteristic brush of mixed pectinate, plumose and simple setae. The inner of the distal endites is narrow and does not extend so far distally as the outer which arises at a different level and is short and unusually wide. Both are similarly armed along an oblique distal edge with long denticulate setae or spines.

The *Maxilliped* (fig. 6, *10*). The coxa is short, with its epipodite sub-quadrangular with rounded corners, its distal margin with a sparse fringe of long setae; the basis is long and is produced into a moderately long endite, the antero-mesial edge fringed along almost its entire length with the characteristic brush setae, about twenty in number, these passing into the distal armature of pectinate setae. There are two long coupling hooks on one maxilliped and three on the other. The whole appendage is fringed with numerous long setae, the propod is expanded, the dactyl broadly ovate. In the female, the coxal lobes of the maxilliped are particularly well developed. They are broad-based and project back, practically at right angles to the coxae, to lie entirely within the brood-pouch almost vertically, fringed along their whole free margin with long curved setae. When the fully developed oostegites of the gnathopods are in position (fig. 7, *10v*), these coxal lobes appear to close the median gap between the small anterior lobes of the first oostegites. It seems quite unlikely that they can play any part in the respiratory movement of water within the brood-pouch, but they form a sieve-like barrier at the anterior opening of the brood-pouch; they probably prevent the accidental escape of eggs, although they may be concerned, also, with the shifting and rearrangement of the developing eggs.

Peraeopods. The coxae of the anterior group of legs appear to be completely fused with their related segments, the actual boundary of the coxa being, in the case of the gnathopod, largely obliterated. In the hinder group, the coxa of the fifth leg is large and triangular and produced posteriorly, but in the two succeeding legs, the coxae are flattened and little produced; they appear, like those of the anterior group, to be united with their segments. All the coxae bear a few setae. In the female, the peraeopods generally are slender and setose.

The *gnathopod* (fig. 7, *11* ♀) is short and the joints relatively stout; the ischium about two-thirds of the length of the basis, merus greatly produced antero-distally, the propod as long as the basis; its palm, little marked off from the posterior margin, swells proximally, but is slightly concave towards the dactyl, bearing about eight slender curved spines and numerous setae; dactyl stout and straight, almost as long as propod, its inner border denticulate along much of its length.

The first oostegite (fig. 7, *10v*) is subdivided into a smaller anterior (and nearly vertical) lobe and a much larger posterior lobe forming the antero-ventral part of the marsupium. The anterior plate is fringed with long setae and is applied to the convex surface of coxa and basis of maxilliped. The following oostegites (fig. 7, *12(2)*) are simple and very large, as long as the related legs, and bear a few fringing setae. The joints of the second to fourth legs are almost linear, but the merus is still seen to be a little produced. On the fifth leg, all the joints, except the basis, are linear and much more nearly sub-equal, the dactyl having the terminal claw movable. Internal to the coxa of the fifth leg, there is found a quite large vestige of a brood lamella as a sub-triangular membraneous flap (fig. 7, *pr.v.*) backwardly directed and overlying the oviducal aperture.

In the male, the gnathopod (fig. 7, *11* ♂ *h*) is much stouter, there is a notable development of the propod, which is a thickened sub-oval joint nearly once and a

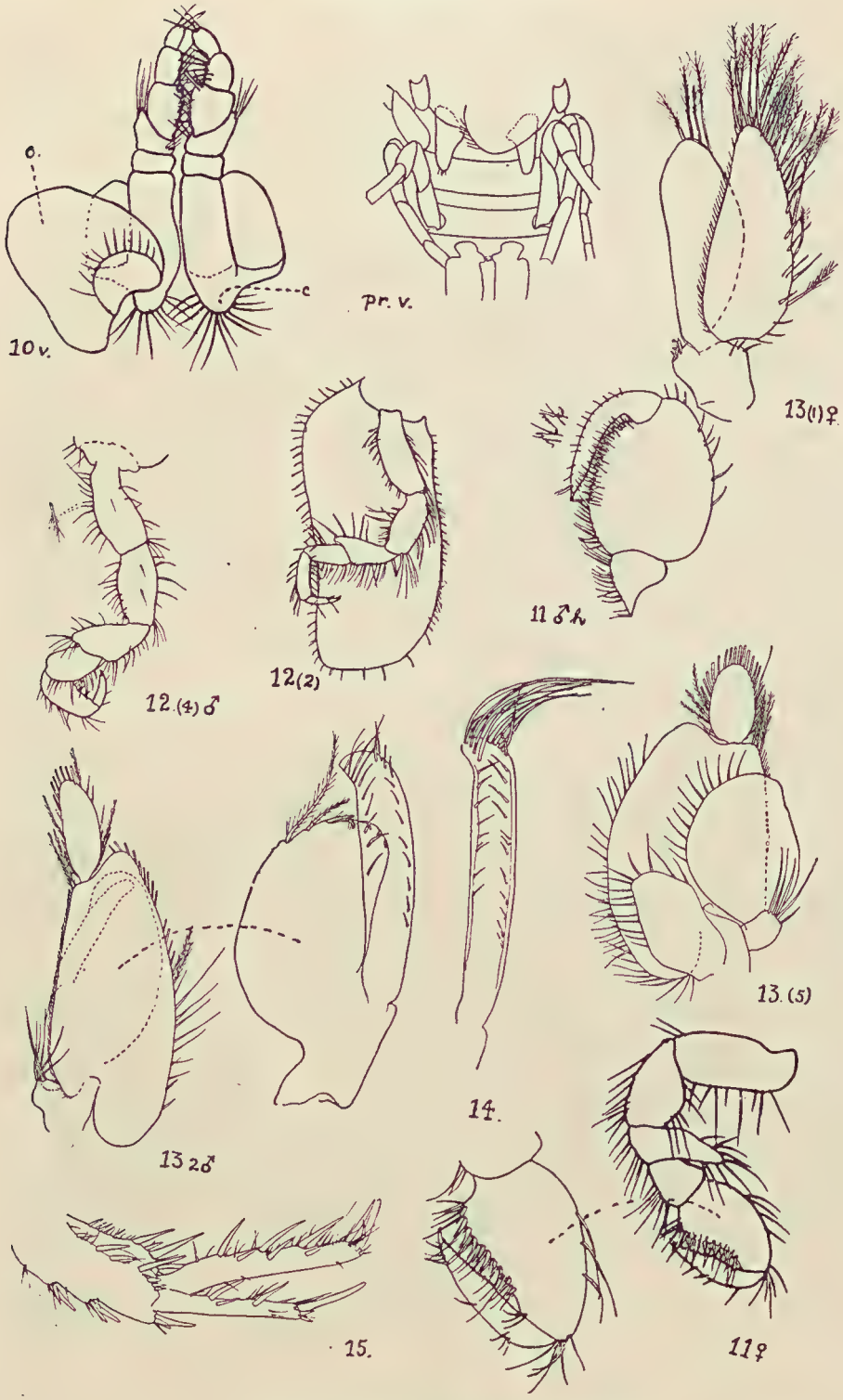


FIG. 7.—*Mesamphisopus capensis* (Barnard).

half the length of the basis. This appendage probably retains the primitive subchelate condition, the oblique palm not being marked off, except for the presence of dentate spines, from the general hinder border of the joint; the dactyl stout (relatively much shorter than in the female) sharply bent near its origin and thereafter nearly straight; its inner margin minutely denticulate for the distal third of its length. The condition of this hand approaches nearly to that found in *Eophreatoicus*.

In the second to fourth peraeopods the merus is moderately expanded anteriorly (again reminiscent of the condition in *Eophreatoicus*), while in the fourth peraeopod the armature of carpus and propod (fig. 7, *12(4)*) suggests that, as in *Amphisopus*, all three terminal joints may be concerned in the sexual modification of this appendage as a prehensile limb. The anterior border of the basis is moderately setose, one or two setae being multi-ciliate and probably sensory. Of the three legs of the hinder group, the fifth is short, the sixth and seventh considerably longer, armed with abundant setae and many spinules; upon the seventh the basis is slightly expanded posteriorly into a thin plate, the maximum width of the joint being about two-thirds of its length. There is noticeable a sub-equality in the length of the several joints of these legs.

From the coxae of the seventh peraeopods spring the small penes, short, bluntly ending, little curved and armed mesially with a few setae. The two are quite widely separated and the condition suggests that this is almost certainly an early phase in the evolution of this structure. In one female (a specimen in the collection of the South Australian Museum), this structure is present, co-existent with brood lamellae.

Pleopods. Barnard's statement that the first pleopod has both lamellae lanceolate in shape and equal in size is true of the male. In the female (fig. 7, *13(1)*♀), the apex of the endopodite is rather more bluntly rounded. In both sexes, both rami carry plumose setae, but these are more numerous in the male, where in the exopodite, they may extend along the distal fourth of the mesial border (about eight) around the apex as far as the proximo-lateral curve. On this margin, there are about twenty-five plumose setae mixed with many simple setae so that the lamella appears almost as setose as in the first pleopod of *N. littoralis*. In the endopodite, plumose setae are restricted to the apex and lateral border and are about twenty-two all told, which, except for *N. littoralis*, is the most setose of any endopodite in the Phreatoicoidea. In the female only about four or five are retained on this inner lamella and these are latero-distal. The sympodite bears from four to six coupling hooks in both sexes, these springing from the mesial and apical part of the widely-rounded mesial coupling lobe, the hooks being minutely barbed. The lateral border of the sympodite has about eight or ten scattered setae (fewer in female), some being sub-marginal in position.

The second pleopod, in the male (fig. 7, *13(2)*) is stouter and longer than the first by the length of the distal exopodite lobe, and both lamellae are wider. The endopodite is ovate (its proximal end being narrow), just extending to the distal exopodite lobe. Its mesial border is separated for rather more than the distal half of its length into a semi-cylindrical penial stylet (fig. 7, *14*); this has an open groove mesially, both free margins being set with spinules and setae; its apex bears eight or nine stout setae, and projects in a fashion unique in this sub-order, but reminiscent of that in many other Isopoda; the lateral border of the endopodite has ten or eleven stout plumose setae not all being shown in the figure. The proximal lobe of the exopodite has a fringe of stiff, short setae along its mesial border, but distally it bears three long plumose setae; half of the mesial border of the distal lobe is similarly fringed with close-set stiff setae, followed

by half a dozen long plumose setae. These continue around to the lateral border of the lobe with about sixteen plumose setae intermingled with a few sub-marginal setules. The proximal lobe has fifteen to eighteen plumose setae laterally becoming shorter as the middle of the lobe is reached; from there they are continued proximally by setae which are not plumed. This sympodite, also, has from four to six strongly-curved coupling hooks at its mesial distal angle and some seven or eight stiff setae. In the female, the endopodite is considerably shorter and bears very few (four or five) plumose setae and the sympodite but one or two coupling hooks with a few entangling setae, these being carried on a distinct lobe.

The third, fourth, and fifth pleopods are more nearly alike, each becoming a little shorter and increasingly wider, the epidodites varying in shape from ovate to oval, but differing little in size; they are armed with long simple setae. The sympodites in the male bear two or three coupling hooks (third), one or two (fourth) and none on the fifth pleopod, while the entangling setae increase progressively in number. The endopodites diminish in size from third to fifth (fig. 7, *13(5)*) and there are fewer setae plumose on the hinder endopodites, although the actual number of setae increases rather than lessens.

In the female, in these hinder pleopods, the setae on the endopodites are very few (four to six) and tend to become simple; on the fifth none are plumose. Coupling hooks are wanting, as in the male, on the sympodite of the last pleopod and there is usually one only on the third and fourth, while the related entangling setae are less numerous than in the male.

The *uropods* (fig. 7, *15*) are slender and the inner border of the peduncle is so greatly developed as to make the joint appear almost laminar. The peduncle appears oblong, but widens distally where its spinose inner edge is most strongly produced, and is surmounted apically by several spines, two of these being particularly stout; the outer edge is very much lower and bears several spines. The intervening surface is nearly flat, but the elevation of the inner margin gives the impression that the surface is grooved. The ventral border of the peduncle has three stout spines supported by clumps of setae and is terminated by a stout simple spine flanked by two smaller. The rami are thin, the inner so tilted that most of its breadth appears in side-view; the inner is one-third longer than the outer which itself is as long as the peduncle, a most unusual condition (cf. *M. tasmaniae*). Both are terminated by a stout movable spine (in the case of the inner ramus, this is flanked by a second equally strong); their crenate upper margins lodge three or four irregularly-spaced spines; there may be many fine setae present but these seem variable.

Occurrence. Under moss in a swiftly flowing stream on Table Mountain, at 3000 feet and above (Barnard, 1914, p. 233).

Colour. Palely grey to dark grey, the appearance being due to scattered black chromatophores on an almost colourless background.

Size. Up to 14 mm.

Mesamphisopus depressus (Barnard)

(Figs 8, 9)

Barnard, 1927, p. 157 *(Phreatoicus capensis* var. *depressus).*

The body, as seen from above (fig. 8, *1d*) is fusiform, its greatest width attained in the fourth peraeon segment, behind which it tapers evenly to the end of the body. The width is less than twice the depth of that segment and about one-fifth of the total length. The scattered setae which cover the body are long

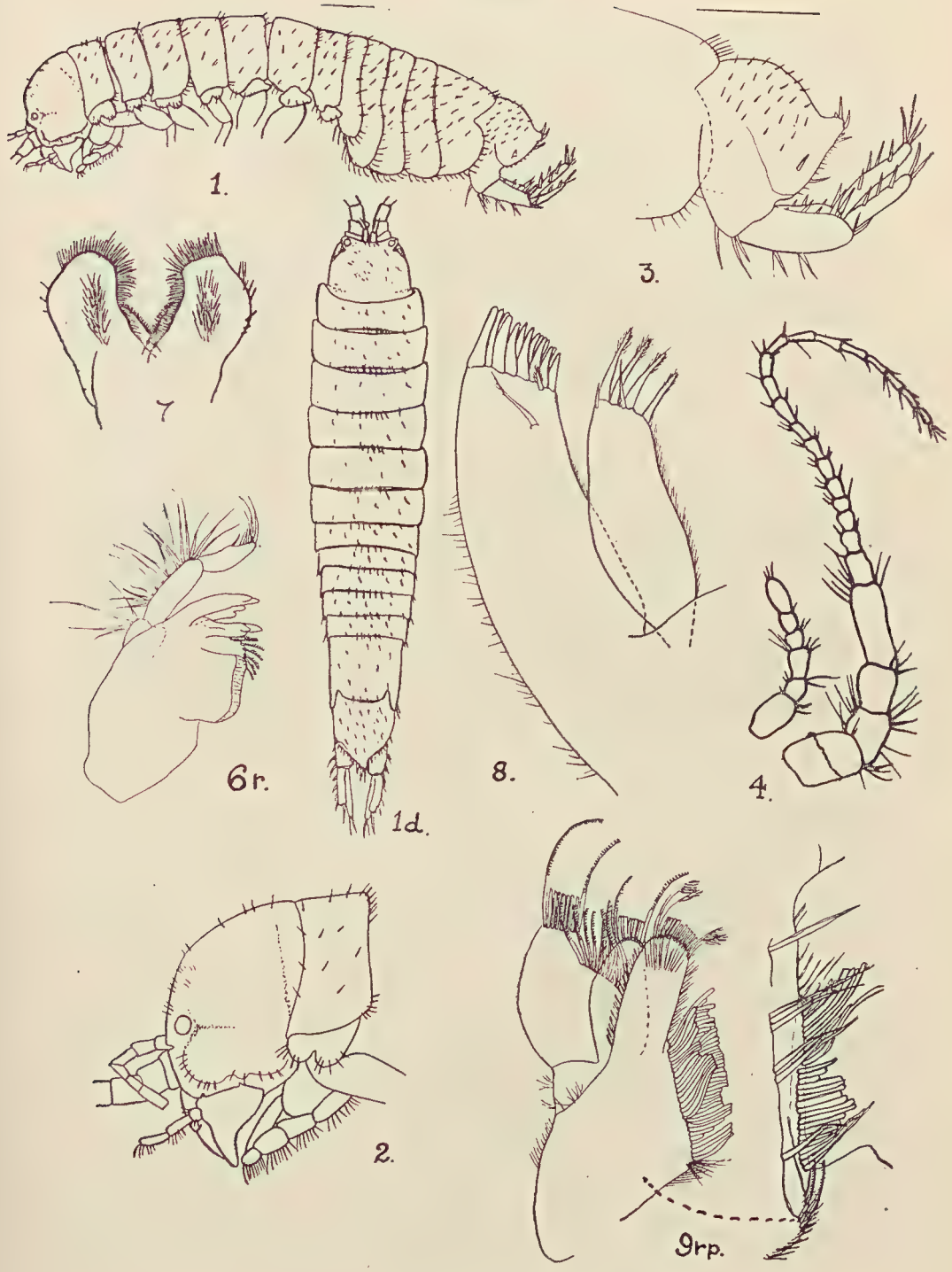


FIG. 8.—*Mesamphisopus depressus* (Barnard).

and even more abundant than in *abbreviatus*. In most segments, there is an incomplete fringe along the hinder border; in the pleon, the stiff setae forming the ventral fringe are still longer and are intermingled with a series of long fine hairs.

The *head* (fig. 8, *2*) differs somewhat in its proportions from that of *capensis*, the cervical groove appears to extend more dorsally; the clustered setae in front of, and external to, the eyes are very noticeable, both antero-ventral and ventro-lateral borders being setose. The eyes have about nine ocelli.

Peraeon. The first segment is relatively much shorter than in *capensis*, so that in this species the head is as long as the combined length of first and second peraeon segments but is otherwise as in *capensis*, anterior and posterior borders being parallel, and the segment scarcely extending forwardly onto the head. The second to fifth segments are sub-equal, the sixth is a trifle shorter and the seventh only one-half as long as the sixth, but distinctly deeper. The first four pleon segments are short, the fifth almost equalling the total length of the second, third, and fourth segments; the greatest depth of the pleon is about twice that of the first peraeon segment, and greater than the maximum width of the body; the tailpiece (fig. 8, *3*) is a little longer than the fifth segment.

Antennule short (fig. 8, *4*), reaching only to the end of the fourth joint of the antenna; its peduncle with second and third joints short, stout, sub-equal, but the flagellum, with three or four joints and minute apical knob, is shorter than the peduncle; where four are found, the first three are sub-equal, the fourth longer and greatly swollen. Apically is borne a cluster of setae including one or two olfactory cylinders. *Antenna* short, moderately stout; the flagellum, with twenty-four joints,[1] is about twice the length of the peduncle. The *labrum* has a deep indentation on one side only, its apical fringe of setae asymmetrically placed. *Mandibles* (fig. 8, *6*), situated very far forward, fulcral process conical; left mandible, principal dentate edge with four teeth, lacinia mobilis with three, first two spines of spine row long, bifid, and denticulate; the palp short with wide joints recalling the condition seen in *Eophreatoicus*, first joint moderately long, with a tuft of stout setae close to its base, second broadened, with numerous long and very slender setae in two rows, but the third joint has usually only one long apical seta and a few (five to six) short simple setae immediately proximal, a condition markedly reduced as compared with *capensis*, where the setae are numerous and extend the greater part of the length of the third joint.

Labium (fig. 8, *7*). This differs little from that of other species of *Mesamphisopus*, except that the apex of the outer lobe appears truncate rather than evenly rounded and the two or three setospines appear indistinctly in the very dense setal fringe.

The *maxillula* (fig. 8, *8*), shows some reduction from the condition seen in *capensis*. The proximal endite bears two simple spines and only four setospines with very few cilia, which are mostly apical. The distal endite usually retains two sub-terminal plumose setae; its apex is armed with about ten stout teeth (all but the innermost, denticulate) and one small setospine; the inner and outer borders of both endites are setose; the condition of this appendage approaches quite nearly that found in *H. plumosus*.

The *maxilla* (fig. 8, *9*) is somewhat variable. In the proximal endite, the basal and distal parts are scarcely defined, the row of filter setae is well developed, but scarcely passes onto the anterior face of the endite; the row of biting setae which lies immediately posterior is more sparse and the considerable gap between

[1] Only nineteen in specimen figured.

the end of this and the distal fringe is edged with fine hairs, and the anterior face bears a sub-terminal rank. In the specimen figured, the filtratory setae appear as a double rank! The inner of the two distal endites is little shorter than the outer. The apical fringe of all is dense, consisting of the usual cluster of mixed setae. The outermost lobe appears narrow, but this is apparently due to the folding of the plate upon itself to ensheath the middle plate. In the dense apical tuft of setae there appear to be one or two spines, much stouter and with coarse denticulation. It is difficult to be sure of this, but the appearance is much like that of this appendage in *Eophreatoicus*.

The *maxilliped* (fig. 9, *10*) is very setose; the large coxa is fringed with setae and bears a rather angular epipodite, the basis is comparatively short, its endite with a long series of brush setae. All the joints are setose, the last three flattened and, in the case of carpus and propod, produced mesially. The dactyl bears several setae on its outer border in addition to a considerable mesial fringe.

The *gnathopod* is not very stout (but the specimen may have been immature); in shape and armature, the hand (fig. 9, *11*) approaches the condition of the female of *Hyperoedesipus*; the dactyl, however, along much of its palmar border, is strongly denticulate.

The *fourth peraeopod* is scarcely modified in the male, the propod being without recognizable palmar spines, but the carpus is strongly spined, and, in all probability, prehensility involves the distal three joints.

Pleopods. The first (fig. 9, *13(1)*) has the rami practically equal in size and oval in shape. The exopodite has a fringe of plumose setae which is particularly dense apically. The lateral border appears to be cleft so that the fringe here is doubled. The straight mesial border of the lamella has a close fringe of short hair-like setae, the rounded apex of the endopodite has a short rank of five or six stout plumose setae, while elsewhere on its border are scattered setules. The lamellae spring by narrow bases from a sub-quadrangular sympodite; the outer border is slightly produced and bears long, lateral and apical setae; mesially a half-dozen coupling hooks project from a short rounded lobe. The surface of the sympodite is covered with setules in tufts suggestive of a development of the scaled condition.

In the second pleopod (fig. 9, *13(2)*) the endopodite (en.) is short and visibly divided into a muscular basal portion and an expanded respiratory lamella, this latter with six or seven stout plumose setae around its free end; the penial stylet (figs 13 (2) and 14) is a widely open scroll-like structure with inner and outer fringe of setules or spinules lengthening towards the apex; as in *capensis*, the actual apex is slightly bent and produced. The sympodite is largely masked laterally and mesially by the proximal lobes of the exopodite, but near its distal end are two or three coupling hooks and as many entangling setae.

In the succeeding pleopods, the exopodite becomes progressively shorter and broader, the endopodite, also, changing in shape, but with its latero-distal plumose setae increasing to a maximum of nine in the fourth pleopod. In the last (fig. 9, *13(5)*) the entire outer border of the endopodite is setose, the fringe consisting of a dozen stout simple setae. There is but a single coupling hook on the third and fourth sympodites, the fifth bears only long entangling setae, six or more in number.

Uropod. The peduncle is sub-oblong, inner border not greatly higher than the outer, both set with a few stout spines; its ventral surface bears several clusters of spines and setae. Terminally, beneath the insertion of the rami is a stout simple spine and two small spines; on the mesial edge just dorsal to these, is one short multifid spine and a short rank of setules. The inner ramus is slightly longer than the peduncle, is flattened (lamellar) and curiously bent near its base. The

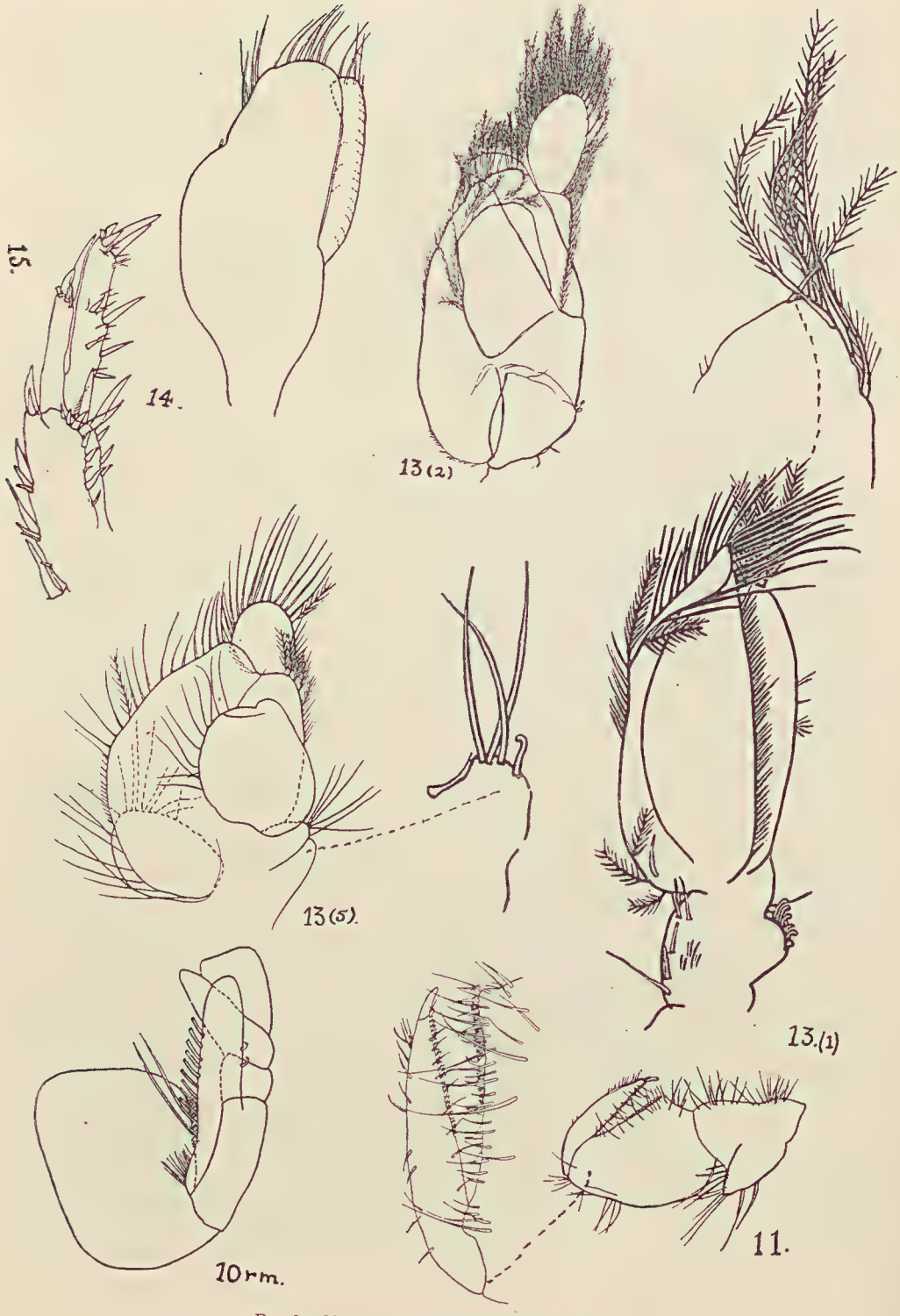


FIG. 9.—*Mesamphisopus depressus* (Barnard).

outer ramus is shorter, both are bluntly truncated terminally and armed with spines laterally and terminally, the spine on the outer ramus being long and highly suggestive of a second joint.

Occurrence. Near the Forest Ranger's Hut in the Steenbras Valley, Hottentots Holland Mts. (Barnard).

Coloration. As in *capensis.*

Size. Probably not reaching 10 mm.

Mesamphisopus abbreviatus (Barnard)

(Figs 10, 11)

Barnard, 1927, p. 157, figs 3-6 *(Phreatoicus capensis* var. *abbreviatus).*

A critical examination of Barnard's variety reveals that it differs from *capensis* in many respects and should be ranked as a distinct species. The description appended relates principally to these differences.

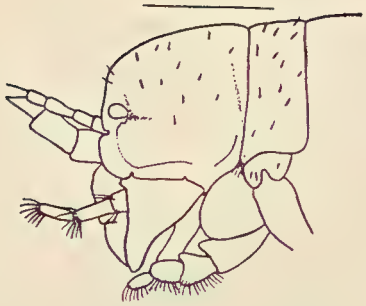
Body sub-depressed (fig. 10, *1s, 1d*), in dorsal view sub-fusiform, the head being little narrower than the peraeon, whereas the pleon tapers quite considerably, the tailpiece being less than two-fifths of the width of the peraeon, which is twice the depth of that region. It is rather more setose than *capensis.*

The *head* (fig. 10, *2*), which is longer than the combined length of the first and second peraeon segments, is a little wider than long and as deep as wide. It rises in front almost vertically from the sub-ocular incisure which is wide and shallow, its anterior border being very shallowly emarginate. The interorbital space is unusually narrow. The mandible lies very forwardly and behind its hinge articulation, the ventro-lateral border dips down steeply to be produced into an unusually long 'posterior process'; the genal groove is short, the cervical groove feebly developed. The eyes larger, relatively, than those of *capensis,* seem variable in shape, being in one specimen sub-oval with long axis antero-posterior, in a second more rounded and long axis vertical.

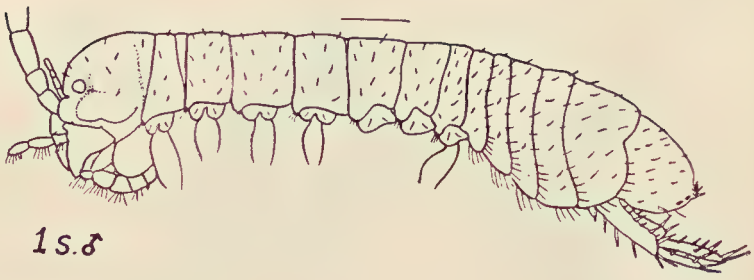
In the *peraeon,* the segments differ noticeably from those of *capensis,* the first is short (about one-third only of the length of the head, or two-thirds of the second peraeon segment), the third more than twice the first; fourth, fifth, and sixth segments are progressively shorter, the sixth being sub-equal to the second, the seventh shorter than, but as deep as, the first, the intervening segments being shallower. Apart from this difference in proportions, the first segment lengthens ventrally (i.e., expands antero-posteriorly) in the male, while in the female, its borders are parallel, but ventrally it is obliquely truncated. The suture of the coxa of the gnathopod with its segment is much more clearly indicated than is the case in *capensis.*

The *pleon* resembles fairly closely that of *capensis* in its proportions, but is more setose, while the pleura differ in shape, being angular at the postero-inferior corner rather than rounded below, the notch between pleuron and tergum of the fifth segment is shallow, the tailpiece ends more bluntly and is shorter (relative to the uropods) and its apex is practically not upturned.

Antennule (fig. 10, *4*). This is very short, having in all but six joints in one specimen (male) and but five in a second specimen, of which three short joints constitute the peduncle; the flagellum, having but two joints and being even shorter than the peduncle, the terminal article longest. It is apparently the shortest antennule of any Phreatoicid at present known, although one specimen of *capensis* has been found with but six joints.

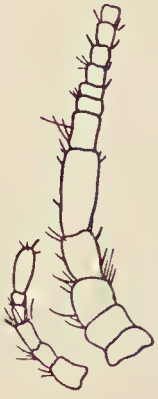


2s. ♀



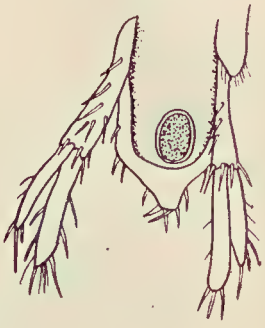
1s. ♂

2s. ♂



4.

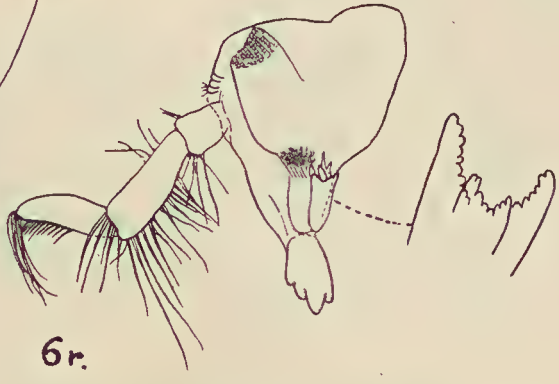
1d.



3v.

3s.

6l.



6r.

5.

Fig. 10.—*Mesamphisopus abbreviatus* (Barnard).

The *antenna* (fig. 10, *4*) comparatively short; peduncle relatively more robust than in *capensis*, fifth joint less slender, flagellum with twenty-four joints, about twice as long as peduncle.

Labrum and *epistome* (fig. 10, *5*), asymmetrical, the unpaired notch for the mandibular palp, although indicated, is less strongly developed than in *capensis*.

The *left mandible* (fig. 10, *6*) resembles rather closely that of *capensis*, but proximal to the strongly developed spine row there are a number of setae (five or six) plumed on one side only. In the right mandible (fig. 6 *r*.) there are four teeth on both principal cutting edge and lacinia mobilis, the latter being minutely denticulate.[1] The palps are as markedly setose as those of *capensis*.

In the *maxillula* (fig. 11, *8*), the proximal endite bears four terminal spines feebly plumed with a parallel row of four simple spines. The distal endite differs from that of *capensis*, principally in that it shows no appreciable narrowing distally; there are two feathered setae on the posterior face.

The *maxilla* (fig. 11, *9*) differs most noticeably from that of *capensis* in that, in the proximal endite, the basal portion is more evidently defined from the distal, although the junction of these makes a much less obvious angle. The outer of the distal endites, too, is unusually broad.[1]

The *gnathopod* (fig. 11, *11*) of the male differs in that the ischium is shorter relatively, the greater part of the posterior border of the propod is bare of setae, the palm being well defined and the dactyl setose and minutely denticulate. The remaining peraeopods call for no particular comment.

In the *first pleopod* (male) (fig. 11, *13*), the lamellae are equal and similar, bluntly lanceolate, exopodite fringed with about twenty plumose setae, distributed along its whole outer border and the distal fifth of the inner border. Just sub-marginal, and widely spaced, along the lateral edge are a dozen stiff slender setae, while on the inner margin there is a dense fringe continuing from the end of the plumose series to the proximal end of exopodite in a single series of very fine setae. As compared with *capensis*, the endopodite has fewer plumose setae (about a dozen) more widely separated and restricted on the lateral border to the distal half, while mesially these setae extend proximally for a shorter distance. There are no simple setae on this lamella. The sympodite (fig. 11, *13(1)*) is sub-quadrangular (widening distally) with a suggestion of a proximal segment, devoid of setae. Distally, on the outer border are four long, simple, marginal setae and one shorter sub-marginal spine, the inner distal angle bears three slender coupling hooks springing directly from the sympodite.

The *second pleopod*. The sympodite is broader distally, its mesial distal angle produced (but without definite lobe) and bears only two coupling hooks and three stiff entangling setae. The outer border is unarmed, but terminally there is one stout sub-marginal spine. The exopodite shows the distal lobe narrow with a length twice its breadth, and bearing about fifteen stout plumose setae. The proximal joint is wide and has twelve to thirteen plumose setae laterally followed by about four or five simple setae towards its proximal end, which is produced into a large, lateral lobe. Mesially, there are a couple, only, of plumose setae distally followed by a multiple fringe of short fine setae passing proximally around a smaller mesial lobe. In the male, the endopodite (fig. 11, *14*) is oval in shape, almost as long as the proximal lobe of the exopodite and bears nine plumose setae around its rounded apex. The distal half of its inner border is separated as a penial stylet, an incomplete, scroll-like tube almost straight but curved and

(1) Cf. *Hyperoedesipus*.

FIG. 11.—*Mesamphisopus abbreviatus* (Barnard).

produced apically, where it carries two long curved setae.[1] Both of the inrolled edges are armed with short, stiff setae. Proximal to this, the basal half of this border is obviously muscular but is not separated from the rest of the endopodite.

The remaining pleopods have each the usual epipodite and show the endopodite decreasing slightly in size and with fewer plumose setae; coupling hooks fewer, generally one only on the third and wanting usually in both fourth and fifth.

The *uropod* (fig. 11, *15*) has a short, deep peduncle which is thin and laminar, its inner mesial edge produced and armed with spines, the two distal being, as usual, the strongest. The ventral edge bears three tufts of mixed spines and setae, and beneath the insertion of the rami, there is one stout simple spine flanked by another similar but much smaller spine. The inner ramus is lamellar, as long as or longer than the peduncle, and bears marginal and apical spines and numerous long setae; the much shorter outer ramus has a terminal spine which may be very long, and, laterally, a variable number of spines and setae; the appendage, as a whole, is apparently quite inconstant in its armature of spines and setae.

Colour. In spirit, dull grey.

Size. Probably not exceeding 10 mm.

Locality. 'Northern Slopes of Kogelberg, in the Southern part of the Hottentots Holland Mountains'. Barnard, 1297, p. 157.

Hyperoedesipus Nicholls and Milner

Nicholls and Milner *(Hyperoedesipus)*, 1923, p. 23.
Sheppard *(Phreatoicoides)*, 1927, pp. 83-84.

Body slender and vermiform, maintaining a nearly uniform width and depth, its length about nine times the greatest width; covered fairly uniformly with long setae, head large and long, its length exceeding both its width and depth; sub-ocular incisure wide and shallow, mandible forwardly displaced, cervical groove feebly developed, posterior process wanting; eyes absent; peraeon wider than deep, with first segment free from the head, very short but greatly expanded ventrally, the second to fifth peraeon segments of fairly uniform size; pleon not greatly shortened, but the pleura almost obsolete; in the female, the fifth segment unusually short; the tailpiece relatively long, not wider than peraeon, its hinder border shallowly emarginate above a small flattened postero-ventral surface. Antennule short, few-jointed, both mandibles with lacinia mobilis; maxilla somewhat reduced and differing on opposite sides; gnathopod, markedly different in the two sexes, being in the male very strong, propod with concave palm, dactyl long; all of the pleopods bear on the sympodite both coupling hooks and entangling setae, exopodite with abundant plumose setae but endopodites without setae and considerably reduced, epipodites wanting. Uropods strongly developed, peduncle produced into strong process mesially at its distal end, terminal spines beneath the rami, short, toothed; outer ramus constricted sub-terminally and produced into narrowed apex.

Genotype. *Hyperoedesipus plumosus*, Nicholls and Milner.

Concerning this genus, Sheppard states (1927, p. 83) that "after careful examination and comparison' of *Hyperoedesipus plumosus* with *Phreatoicoides gracilis*, she was convinced that 'the difference between the two are not sufficient to justify the formation of two distinct genera'. Accordingly, the name *Hyperoedesipus* was relegated to the rank of synonym of *Phreatoicoides*. It would, indeed,

[1] As in *Hyperoedesipus*.

not have been unreasonable to have formed this opinion had it been based on no more than the original description (1923), marred as that is with its regrettably numerous errors and omissions, these latter including several of the more significant features. But after 'a careful examination' of an actual specimen, attention should have been called to the more obvious mistakes, and some, at least, of the omissions remedied, and in that case it might well have been expected that a different opinion would have been formed.

The oversight in the original account of two of these characters, which were really quite obvious, and are of considerable importance, is inexcusable; they are:— (1) the presence of a lacinia mobilis on both mandibles, and (2) the occurrence of coupling hooks, associated with long setae, on the sympodites of all the pleopods. It was unfortunate that in a revision of the family, these details, at least, were not observed; on the contrary, in the case of the first, Miss Sheppard repeats our error, stating (l.c. p. 119) 'the right mandible does not bear a lacinia mobilis'.

The occurrence of coupling hooks *on all the pleopods*, invariably associated with long entangling setae, provides a character found in no other genus. In the writer's view, this is the retention of a primitive condition, from which could have been derived that found in other Phreatoicids; for the Amphisopine forms have coupling hooks on some pleopods without setae and the typical Phreatoicids have lost coupling hooks but have retained and even augmented the group of long setae.

Further, the marked difference in the position of the mandibles and in the proportions of the tailpiece of the two genera were not observed. That these differences between *Hyperoedesipus* and *Phreatoicoides* could be overlooked when the two species are placed side by side is surprising.[1] In the former, the tailpiece of the male is no wider than the peraeon and in the female rather narrower, whereas in *Phreatoicoides* the tailpiece is, in both sexes, wider than the rest of the body, making a quite conspicuous swelling when seen from above and constituting a feature peculiar to that genus;[2] while the forward displacement of the mandibles in *Hyperoedesipus* has no exact parallel in other Phreatoicids, although most nearly approached in some *Mesamphisopus* species.

Although failing to correct these errors in our description, Miss Sheppard questions the accuracy of our statement that in the peraeon the first segment is half or less than half the length of the second. In the many specimens which were examined, some inconstancy was found, the length varying from one-third (in some females) to almost half (in typical males). It is, however, greatly expanded below to extend forwardly upon the head exactly as in other Amphisopine forms, so that the general appearance of this region is strikingly different from that of *Phreatoicoides*, where the first segment (which, too, is variable in length) may be almost, or quite, as long as the succeeding segment, and scarcely, or not at all, forwardly produced.

The slender sub-cylindrical body, with a coat of very flexible setae, the absence of eyes, the elongate antennae and reduction of maxillula and maxilla, the massive hand on the gnathopod, slender peraeopods with no widening of the bases in the hinder group, the shortening of the penial stylets, and the striking reduction of the endopodites in the pleopods and of the pleura in the pleon, are all features reasonably to be attributed to adaptation to life in subterranean waters. Probably, many of these features have been developed independently several times in Phreatoicids in widely separated localities. An elongation of the head (particularly in the post-mandibular region) and the general elongation of the body, resulting

(1) No specimen of *Phreatoicoides* was available to us when the account of *Hyperoedesipus* was published.

(2) Perhaps, *Hypsimetopus*, also.

in a more nearly uniform length of the segments in the peraeon, may likewise be features related to the mode of life. There is yet another character which may perhaps be adaptative, to which it appears attention has not been directed—viz., the flattened posterior surface of the telson in these subterranean forms. There is here not the shortened stump of a telsonic spine, found so generally in Phreatoicids, but the variable development of a wide, flat, postero-ventral surface, onto which the anus opens, this condition being (hitherto) recorded elsewhere only in *P. assimilis*. Actually it occurs in *Phreatoicopsis, Phreatoicoides, Notamphisopus*, and, probably, in *Hypsimetopus*.

On the other hand, in the retention of a relatively longer pleon, of the lacinia mobilis on both mandibles, of more numerous spines (simple and setose) on the inner endite of maxillula, of coupling hooks on the sympodites of all the pleopods, of a fringe practically completely composed of plumose setae on the exopodite, and of the almost laminar condition of the rami of the uropods, there are found characters which not only mark the more primitive Phreatoicids, but which sharply distinguish this genus from *Phreatoicoides*. Although the penial stylets are short in both genera, they are otherwise quite unlike, that of *Hyperoedesipus* differing little from the condition found in *Mesamphisopus*, whereas that of *Phreatoicoides* appears to be reduced from the condition in *Phreatoicopsis* or *Amphisopus*.

If, then, there are excluded the features enumerated as adaptations to life in waterfilled underground crevices, the parallel loss of epipodites is almost the only significant feature recorded that is common to the two genera which Miss Sheppard would unite. Giving due weight to all the facts, it would seem that the separation of *Hyperoedesipus* from *Phreatoicoides* is fully warranted. Further, it seems probable that the two genera are not even closely related, most of their 'likenesses' being attributable simply to parallel and even convergent evolution as a consequence of adaptation to a precisely similar mode of life. *Hyperoedesipus* seems to find its nearest kinship in the South African *Mesamphisopus*, both presumably being descended from a common Gondwanaland ancestor.

Hyperoedesipus plumosus Nicholls and Milner

(Figs 12, 13)

Nicholls and Milner, 1923, pp. 23-33, pl. 2-5 *(H. plumosus)*.
Sheppard, 1927, p. 129 *(Phreatoicoides plumosus)*.

In many details, the original account is misleading, important features being omitted or insufficiently stressed; it is desirable, therefore, that a more correct description should be available, the more so as the species may be nearing practical extinction.

Body (fig. 12, *1d*, *1s*) slender, vermiform, tapering not at all, although there may be an insignificant narrowing of the head anteriorly, and, also, of the end of the tailpiece; the length is nine times the width which is practically uniform, and, in the male, is greater than the depth; in the female, the body is broader, so that the length is little more than eight times as great as the width, which is almost equal to the greatest depth of the pleon; the surface smooth with fine setae scattered generally, but an arrangement of these in transverse rows is suggested on some of the pleon segments.

The *head* (fig. 12, *2s*) is moderately large, sub-quadrangular in dorsal view, its anterior border concave; a sub-ocular incisure is well marked, and from this the front seems to rise more steeply in the female than in the male. Below the

FIG. 12.—*Hyperoedesipus plumosus* Nicholls and Milner.

incisure no sub-ocular segment is discernible and the mandible extends with an oblique articulation *to the extreme anterior margin* of the head. Eyes, genal groove and cervical groove all are wanting unless a faint upward continuation of a seta-bearing ridge, rising from the ventro-lateral border of the head, is the last vestige of the latter. Behind the mandible, the ventro-lateral border of the head is practically horizontal but is sharply downturned posteriorly. The 'posterior process' underlying the hinder angle of the body of the mandible in many Phreatoicids is here wholly wanting. The hindmost head appendages seem to be attached very far back, below the wide intersegmental space separating head from peraeon, they lie, nevertheless, anterior to the bases of the gnathopods.

In the *peraeon* there is, in the male, a near approach to uniformity in the length of the segments with the exception of the first and last; the first is quite short in the mid-dorsal line but expanded greatly ventro-laterally, so that it may be produced forwardly to overlap the head, from which, however, it is wholly free! In the female, this segment is short, but the ventral expansion is notable. The sixth and seventh segments are sub-equal, but shorter and deeper than the preceding segments in the female; in the male the seventh is more markedly shortened.

In the *pleon*, the first to fourth segments are sub-equal; in the female, the length of the fifth segment is equal to that of the third and fourth combined, and its depth almost uniform, whereas in the male, the fifth is longer and practically equal to the combined length of segments one to three, its depth, however, decreasing considerably posteriorly, so that the body can be seen to be constricted at this point.[1] This appearance of constriction is not entirely due to the oblique truncation of the fifth pleura for it may be seen (in the male, at least) in dorsal view. The free border of the fifth pleuron is fringed with long setae.

The *tailpiece* (fig.12, *3s*, *3d*) is as long as the three preceding segments combined, is narrow anteriorly, widens mesially and contracts posteriorly. In side view, the terminal part is bent sharply ventrally to end abruptly at the shallowly concave posterior margin, the lateral corner of which appears, in side view, as the hindmost point of the body. Below are slight telsonic pleura with a fringe of setae; the dorsal line of insertion of the uropods is continued anteriorly in a suture armed by two or three setae. In front of the uropod, the sixth segment has a straight pleural edge; it is carried horizontally in life and bears a fringe of ten to twelve long setae.

Antennule shorter than the peduncle of the antenna, with a maximum (rarely attained) of eight joints, the penultimate long and swollen, the last a mere knob with terminal setae and olfactory cylinders. *Antenna* exceeds half the length of the body; peduncle with first and second joints short and sub-equal, third, fourth, and fifth becoming progressively longer and more slender, the fifth once and one-half to twice the length of the fourth; flagellum, with about thirty joints, almost three times the length of the peduncle.

Labrum (fig. 12, *2s*, *5*) markedly asymmetrical, very large, relatively short and wide, with a fringe of short setae, extending ventrally on the under surface; laterally, the lip is excavated on its posterior surface where the fulcral process of the mandible abuts against and underlies it.

Mandibles (fig. 12, *6*). These, though showing considerable reduction, retain the characteristic Amphisopine condition. The right mandible has a cutting edge with four bluntly rounded teeth and a slender lacinia mobilis furnished with two

(1) In *Phreatoicoides gracilis*, the pleura of this segment have become practically obsolete posteriorly, so that this constriction is wholly exposed and appears much more marked in that species.

or three small, sharp teeth which are minutely denticulate (fig. 12, *6rs*). The fulcral process is conical and unusually long, its free anterior end concealed, in the undissected specimen, by the labrum. The spine-row appears as a double row of toothed spines (about three pairs) followed by a short series of four ciliated spines. The molar is long and slender, a group of three ciliated spines springing from its distal edge. The palp has a long third joint but the number of setae is considerably reduced, there being about three terminal longer setae and six to nine shorter, situated more proximally. In the mandible, dissected free, the adductor muscle is seen (fig. 12, *6lm*) to occupy a small rounded opening well behind the molar and near to the posterior end of the body of the mandible. In the left mandible, the lacinia mobilis has the normal condition of a fairly strong cutting plate, both this and the principal dentate edge variable with three or four teeth. In both, the molar surface suggests a series of parallel pectinate (biting) setae, the distal ends of which appear, in many cases, free and projecting beyond the molar surface.

The *labium* (fig. 12, *7*). In all the preparations this structure appears asymmetrical, perhaps due to a distortion sustained in dissection, for it is particularly flimsy and easily damaged. Buried in the very dense fringing setae on the distal and mesial aspects of its paired lobes there seem to be several setospines. In the figure only a few setae are represented.

Maxillula (fig. 12, *8*). The proximal endite is small, its apex truncated, bearing four setospines, against the first and third of which is a simple spine. The distal endite is armed apically by twelve stout spines. A single short, stout, plumose seta occurs on the posterior face of this endite, whose outer edge bears a series of spinules and sub-marginally at about its mid-length a cluster of slender, finely pectinate setae.

The right *maxilla* (fig. 12, *9*) in this species closely resembles that of *M. depressus*, but appears rather variable and has, generally, undergone rather more reduction, while still further reduction has taken place in the case of the left appendage. The proximal endite is sub-triangular in shape, and in the right appendage, the comb of filtratory setae is well developed, although the cilia on these setae are very fine indeed. This row is backed only by a very short posterior line of four or five setae usually, but not invariably, pectinate; proximal to the filtratory series there may be a short tuft of stouter setae (doubtfully pectinate) and this proximal part is fringed with a series of fine, simple setae. Distally to the filter setae the inner border is bare but the apex of the endite, which may be truncate or bluntly rounded, bears a single row of about fifteen pectinate setae, some of which are very stout; the middle lobe has its hinder face and its inner border setose, its apex with a dozen stout pectinate or denticulate setae; the outer lobe is short and unusually broad, its apical setae forming a dense double series. The faces of this endite are free from setae; but proximal to its base, on the outer border of the appendage is a short series of about five setae which spring apparently from the second segment. The *left maxilla* is unique in this sub-order in that the filtratory setae are absent, the whole mesial edge bearing a continuous fringe of short, hair-like setae, the pectinate series reduced to two (rarely four) setae.

Maxilliped (fig. 12, *10*♀). Like the maxillula and maxilla, this appendage is very flimsy and proves surprisingly difficult to remove undamaged. The coxa is short and broad and bears a rather narrow elliptical epipodite, which is generally unarmed laterally but occasionally with a proximal fringe of setae and with a broad but scattered fringe of short, fine setae mesially. Near its base are numerous

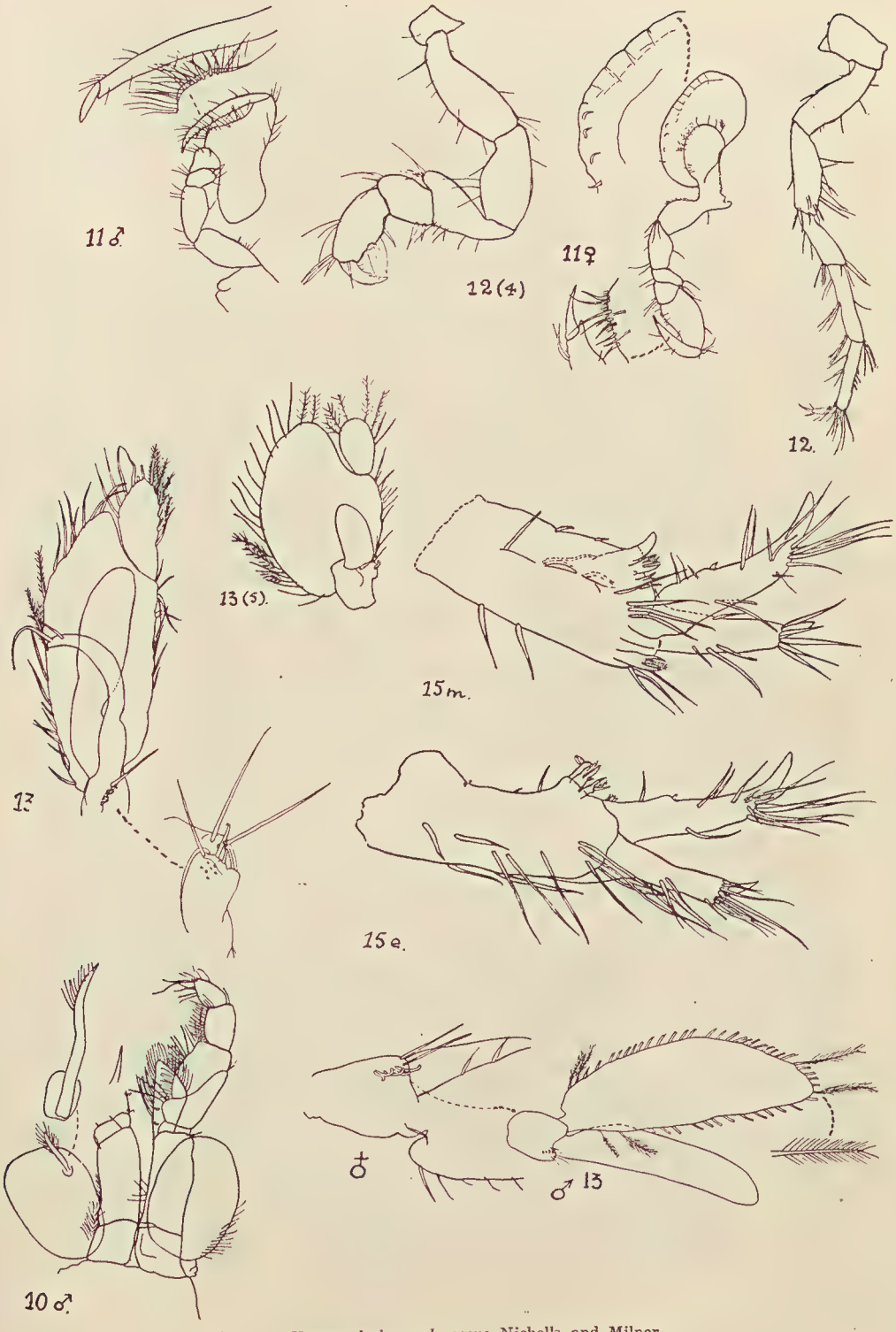


FIG. 13.—*Hyperoedesipus plumosus* Nicholls and Milner.

short lines of very fine setae which here, as in other species, are regarded as the free fringed edge of reduced scales; the basis long, its length more than twice its width; its mesial (posterior) edge set with scale-fringe setae, its antero-mesial edge with a band of short, stiff setae; at its distal mesial angle is the usual stout plumose spine (not shown in the figure); the endite is fringed along its whole length with long and stout setae, of which the more distal eight or nine are typical brush setae; in the hinder mesial edge are two or three stout many-barbed coupling hooks; the apex bears a dense tuft of setae mostly of the biting type. The ischium is, as usual, short, the merus produced distally, the entire inner edge of carpus and of much of the propod with close-set stout simple setae; the sub-oval dactyl has four or five apical setae, its outer border practically unarmed. On the inner aspect of the epipodite of one specimen (fig. 13, *10* ♂) there is found a stout, partly plumed spine, arising from a shallow pocket. Little significance would attach to such a variation were it not that in one other Peracaridan group (the Apseudidae), a similar plumed process arises normally from the epipodite as part of the respiratory apparatus.

All of the peraeopods have basis and ischium practically of equal length. The anterior four peraeopods are relatively short, basis, ischium, merus, and carpus all appearing short and wide and in all of these, the merus shows some production antero-distally. In the gnathopod of the male (fig. 13, *11*) the propod has developed an immense antero-proximal lobe of sub-quadrangular shape, this joint reaching a length more than twice that of the basis, while the slender dactyl is longer than the posterior border of the propod, greatly over-reaching the palm. This is concave distally, convex proximally, with an irregular knife-edge and armed with a few short spiniform setae, a group of more numerous slender, simple setae occupying the rounded hinder angle. The dactyl seems to have a movable claw and a distinct secondary unguis.

The fourth peraeopod is sexually modified in the male to form a sub-chelate hand (fig. 13, *12(4)*), the stout dactyl capable of closing down on to the propod, the palmar surface of which is provided with two strong spines; the propod, too, is excavated proximally and can probably close down partially onto the large spine on the carpus.

In the female gnathopod (fig. 13, *11* ♀) the propod is much smaller, more normal in shape, lacking the anterior prolongation; its palm is not defined and its armature is simpler; the fourth peraeopod differs little from the third.

In the gravid female, the brood-pouch attains to a very large size, and, because of the slenderness of the animal, is clearly visible in dorsal view (fig. 13, *1d.* ♀). As many as seven juveniles have been found together, these reaching a length of about 2 mm. but normally there are no more than four embryos in the pouch. This has the usual four pairs of lamellae borne on the four anterior peraeopods and not, as stated in our earlier account (1923, p. 31) on third to fifth peraeopods. Such a mistake was possible owing to the curious backward displacement of the pouch and to our unwillingness to sacrifice for dissection the only female specimen then available. There is, however, as in *Mesamphisopus*, a small vestigial lamella on the fifth segment. It is curious, and possibly more than a coincidence, that Barnard (1914, p. 237) and Sayce (1899, p. 136) both fell into a similar error when describing the condition of the female of *capensis*[1] and *gracilis* respectively. In all three species, the first lamella is backwardly displaced[2] and in the two

[1] Subsequently corrected, 1927, p. 147.

[2] Related to the fact that the gnathopod is not forwardly situated in this species.

latter, at least, set so nearly vertically that it is not distinguishable without dissection. In *Hyperoedesipus* the anterior lobe of this divided lamella is small and fits closely against the coxa of the maxilliped and the coxal lobe of that appendage is reduced, appearing as a small undivided plate with but few hooked setae, disposed vertically in an oblique antero-lateral plane, the pair closing the median gap between the anterior lobes of the first pair of oostegites. These latter are small, the anterior plate oval with short plumed setae, the hinder portion larger with three or four marginal setules (fig. 13, *11*♀).

The three peraeopods of the hinder group are longer, increasing progressively in length, with all the joints slender. In life, the fifth pair are almost invariably carried upturned, above the level of the dorsal surface.

The *pleopods* (fig. 13, *13*) are distinctive, for, although the endopodites have undergone greater reduction in size than in any other Phreatoicid, except possibly *P. gracilis*, and in the three hindermost, the epipodites are wanting, yet the coupling hooks remain better developed than in even the most active of surface-living forms and are, moreover, associated with entangling setae. On the first pleopod there are variably from four to seven coupling hooks and three setae, while the fifth has four long setae and but a single coupling hook. Associated with the retention of this full development of the coupling mechanism (a natatory device) may be the fact that, in this species, the plumose setae on the *exopodite*, likewise, reach their maximum development, commonly fringing the *entire mesial border* as well as occupying the whole lateral border to its proximal end. Here, as elsewhere in this species, there is some variation, simple setae replacing plumose setae occasionally and the mesial fringe is sometimes sparse. The unusual occurrence of plumose setae springing even from the extreme *proximal* end of the exopodites might be supposed to be a development made possible with the gain of freedom from the restriction of pleura. It should be noted, however, that in *Phreatoicoides*, where the pleura have become even more reduced, both exopodite and endopodite are practically bare of setae of any kind, and in *Hypsimetopus*, where even the endopodite may retain plumose setae (first pleopod), the proximal part of both lamellae bears comparatively few setae, none of which are plumose. It seems probable, therefore, that in this abundant development of plumose setae, as in the related persistence of a complete coupling mechanism, *Hyperoedesipus* shows further evidence of a primitive condition and of its affinity with *Mesamphisopus*.

In the male, the penial stylet on the second pleopod is unusually short, curved along its whole length, but otherwise approaching most nearly the condition of that of *Mesamphisopus*. It is, however, armed solely with terminal setae, two in number, fringing setae being absent. In one example, the distal lobe of the exopodite attains a quite unusual size, approaching that of its more proximal lobe.

Succeeding pleopods tend to become shorter and the exopodite broader, coupling hooks fewer, and entangling setae more numerous, until in the last only one coupling hook remains with about four long setae. This coupling mechanism springs from the swelling inner border of the sympodite rather than from distinct lobes, except in the fifth, where a well-marked lobe is present. The endopodite of the fifth is much smaller. The armature of setae along the mesial border of the exopodite is noticeably variable and a couple of simple setae (which may be submarginal) may be found even on the distal lobe.

Uropods (fig. 13, *15*). These appear short in comparison with the long tail-piece; actually, if compared with the length of the body, they are longer than in *Phreatoicoides*. The peduncle is stout and sub-cylindrical, but the median dorsal

edge is produced vertically into an uneven lamina armed with a few spinules, and its mesial distal angle produced into a small process which is rather variable in size. The outer upper border is armed with long slender setae, while on the inner aspect there are a few setae at about the same level. The ventral surface of the peduncle also has a few long setae but no spines, the usual terminal spines beneath the rami represented here by two or three strong setae. On the dorsal surface, however, and passing obliquely to the ventro-lateral corner of the inner side is an incomplete row of rather peculiar trifid spinules which are probably represented in other species by the toothed terminal spines. The outer ramus is shorter than the inner; both are produced to a point terminally, but it is difficult to decide whether or not there is here a terminal movable spine; both bear a sub-apical circlet of setae and in the outer ramus, at least, the ramus is constricted abruptly at the base of the spine, which is flanked by two or three strong spines as in *Mesamphisopus*. The upper border of the inner ramus is produced into a thin irregular vertical lamina and there may be one or two spines as well as scattered setae, in this again recalling the condition of *Mesamphisopus*.

The dorsal telsonic border (fig. 12, *3d*) is emarginate and overhangs, as a thin transparent plate, the end of the body which forms a wide, flattened sub-triangular or almost semi-circular surface, and is directed obliquely postero-ventrally. The anal opening is slit-like, visible, as in *Phreatoicopsis*, both from behind and below, and it is this, slightly open, and seen through the upper surface, that gives the appearance of a sub-terminal notch figured in our original account (1923, pl. 5, fig. 11).

Colour. In life, whitish, translucent, the intestine showing through as a black thread; in spirit, becoming a dull opaque white.

Size. Largest male 10 mm.; female, with brood-pouch, 7 mm.; juvenile, still within the pouch, 2 mm., nearly.

Locality. Known only from a spring below Lesmurdie Falls, in the Darling Ranges, about 15 miles south-east of Perth.

Although subterranean Amphipods are found in various localities in Western Australia, this is the only subterranean Phreatoicid so far known there, and its interest is considerable in view of its kinship to *Mesamphisopus*. Discovered nearly eighteen years ago, it has since been sought without success over a wide area. It is apparently to be found only in the outflow of this one tiny spring which is markedly intermittent, never flowing for more than a few consecutive days and in some seasons failing completely. Further, since the proclamation of the Lesmurdie Falls area as a National Reserve, the locality has become much more frequented and increasingly subject to disturbance. Still more serious is the fact that the creek below the Falls is changing its course and has now reached a point within a couple of yards of the spring, the tiny pool into which this once discharged having already disappeared. Apart from that, specimens, never numerous, have become increasingly scarce in recent years. During the winter of 1941, four collecting trips were made, two quite fruitless, one secured five examples only, and another (following a week of gales) yielded more than a dozen. Attempts made repeatedly to keep specimens alive under laboratory conditions have failed completely, all the specimens invariably dying in a few weeks, although many precautions were taken; the species seems to be very intolerant of light; probably, too, it normally lives in water highly charged with oxygen.

When in movement, the pleopods hang vertically, freely exposed, and, if kept under observation in the laboratory in a glass dish spread with a thin film of silt, it is frequenty found that the body is so carried that the pleopods sweep

the ground, the creeping movement leaving a trail made by these appendages. In such circumstances, the uropods may, also, drag and kick upon the surface. Usually, however, the pleon is carried well clear of the surface (neither pleopods nor uropods touching), with uropods widely spread like the pincers of a forficulid, the trail then made being slight, principally the work of the gnathopods which are carried well forward, continually clawing at the surface. If there is a sufficient depth of mud, the animal quickly burrows out of sight, employing the gnathopods for this purpose, and it is noteworthy that in practically all Australian burrowers or subterranean forms the gnathopods are exceptionally large. Curiously, the New Zealand subterranean species are not possessed of large gnathopods, so that it seems unlikely that the increased size of these appendages is primarily related to the burrowing habit. In *Hyperoedesipus* the immensely disproportionate size of these, in the male, is probably related to the strain liable to be put, while mating, upon its earth-hold, the breeding season apparently corresponding with the period of most rapid flow in the underground waters. Such observations as have been made indicate that the female is actually gripped only by the fourth peraeopods.

Sub-family II. AMPHISOPINAE

Body robust, scaly; head short with cervical groove reduced or wanting; eyes large, prominent, with many ocelli; first peraeon segment short, fused with head which it overlaps in front; telson rounded or emarginate, not produced. Antennule long, filiform; antenna moderately long; coxae of peraeopods fused with their segments, bases of hinder peraeopods broadly expanded, dactyl long; pleopods, with endopodites reduced and without plumose setae; coupling hooks on sympodite of at least first two pleopods, but entangling setae absent on first pleopod; both first and second pleopods modified in the male; penial stylet stout, strongly curved and tapering, without terminal setae; uropods styliform with rami truncated and armed with stout, freely movable, terminal spine. Brood-pouch contains numerous young.

There are included two genera, *Amphisopus* and *Paramphisopus*, both with two species, and both Western Australian. They are unquestionably related, but differ in one or two important features—the condition of the fourth peraeopod in the male, and of the gnathopod. That, of the two, *Paramphisopus* is more primitive in respect to the former seems probable—the particular style of sexual modification of this appendage found in *Amphisopus* is peculiar to that genus and is almost certainly an independent development unrelated, or practically so, to the modification of this appendage in other sub-families. On the other hand, in the like condition of gnathopods of the two sexes *Amphisopus* probably retains the more primitive condition, while the marked difference of this appendage in male and female of *Paramphisopus* may be a consequence of the failure to develop a sexual modification of the fourth.

The shortness of the head and the loss of cervical groove are features common to both genera, apparently related to the forward displacement of first peraeon segment.

The toothed condition in *Amphisopus* of the large spine beneath the insertion of the peduncular rami is a feature Phreatoicine rather than Amphisopine.

Paramphisopus, gen. n.

Body robust, *head* short, sub-ocular incisure slight, posterior process developed, but cervical groove practically obsolete. Eyes very large and prominent. *Peraeon*

scarcely compressed (sub-depressed), posterior margin of segments without setal fringe; telson slightly projecting, hinder border convex. *Antennule* scarcely longer than peduncle of antenna. *Gnathopod* markedly different in male and female, fourth peraeopod of male not sexually differentiated, coxa of fifth, sixth, and seventh peraeopods so completely fused with segment that even the suture may be obsolete (in *palustris*), and with basis only moderately expanded; both first and second pleopods modified in the male, coupling hooks not occurring on the three hinder pleopods, but entangling setae are present and these may be pectinate; the terminal spine on the peduncle of uropod, beneath the insertion of rami, is simple.

Genotype. *Paramphisopus palustris* (Glauert).

With two species, *palustris* (Glauert) and var. *fairbridgei*, var. n., and *montanus*, sp. n.

Paramphisopus palustris (Glauert)

(Figs 14, 15)

Glauert, 1924, p. 49 *(Phreatoicus palustris).*
Nicholls, 1924, p. 92, pl. 8, figs 2 & 2a *(Phreatoicus palustris)* and 1926, p. 182 *(Amphisopus palustris).*
Sheppard, 1927, p. 115 *(Phreatomerus palustris).*

In order to facilitate the comparison of the different species of the Amphisopinae, it has seemed desirable to describe, in considerable detail, one of these lowland forms. For this purpose *P. palustris* (Glauert) has been selected. It is not an extreme type and is, moreover, a form of very common occurrence, which may be taken freely in many of the coastal swamps and lakes in the neighbourhood of Perth, W.A. Further, it attains to a moderately large size, and is thus a convenient subject for detailed study. The original description is quite incomplete.

Body fusiform, surface smooth; *head* (fig. 14, *2*) rounded, approaching quarter-spherical in shape, rather shorter than the combined length of first and second peraeon segments, distinctly broader than long, its greatest depth rather less than its width; anterior margin is excavate, the concavity lodging the antennae which are separated in the middle line by a narrow vertical *ridge* (possibly a vanished rostrum); sub-ocular incisure minute; the infero-lateral margin produced forwardly in a 'posterior process'. The posterior border of the head, for much of its extent, is hidden by the obliquely overlapping anterior border of the first peraeon segment. The actual postero-ventral angle is obscured by the coxa of the gnathopod, anterior to which is a ridge. This may be the persistent, lower part of the ridge which borders the cervical groove in *Mesamphisopus capensis*. A short and shallow vertical groove below the eye, extending to the ventral border of the head parallel to the anterior border, partly defines the sub-ocular lobe, behind which is an ill-defined genal groove. Owing to the downward curve of the ventral border of the head, the cheek becomes much deeper where its margin comes into contact with the lateral border of the epipodite of the maxilliped.

The eyes, situated very close to the anterior margin of the head, are many-facetted and prominent, sub-circular or reniform in outline, with about sixty ocelli;[1] they are more prominent in the male.

Antennule (fig. 14, *2s*) shows the first joint of peduncle stout and twice as long as broad, the second barely three-fourths the length of the first and distinctly more slender, while the third is usually more than two-thirds of the combined

[1] Bouvier, *fide* Richardson (1905, p. 132), states that in Isopods the number rarely exceeds thirty to forty.

FIG. 14.—*Paramphisopus palustris* (Glauert).

length of the two more proximal joints but is scarcely stouter than the flagellum. This is slender, slightly tapering, little exceeding the peduncle in length, and consists of nine joints in the male and ten (the last a mere knob) in the female; on most joints is a terminal circlet of fine setae and, in the male, a single olfactory cylinder on segments six to eight. Most of the joints are covered with fine setae. In the female, an olfactory cylinder is found on each of the fifth to the ninth articles.

In the *antenna* (fig. 14, *2s*) the peduncle is much stouter, the first joint very short, second rather longer, both very broad, the third slightly narrower and longer than the second joint; the fourth almost as long as the combined length of the second and third, while the slender fifth is rather less than the second, third, and fourth together. The flagellum may be twice as long as the peduncle, with twenty-nine joints (some of the more proximal appearing to be undergoing further segmentation), becoming increasingly slender distally, the joints towards the apex being two or three times as long as wide. In addition to the few scattered spiniform setae which occur upon the peduncle, there is a fur-like covering of fine setae, and this is found on some of the flagellar joints, also, while a circlet of fine setae fringes the end of every joint of the flagellum. In the unmutilated state, the second antenna may have a total length three-quarters of that of the body.

The *labrum* is slightly asymmetrical (fig. 14, *5*) but roughly semi-circular in shape, deeper than wide, the ventral margin generally setose, the short, curved setae being particularly dense towards the mid-ventral region; the free ends of these setae are directed backwardly (i.e., towards the mouth). On either side of the anterior (fig. 14, *2a*) surface is a conspicuous broken line of longer setae, partly visible on lateral borders (fig. 14, *5*). These are better developed in some Amphisopine forms, but unrepresented in the Phreatoicinae.

Left mandible (fig. 14, *6l*). The cutting edge with four teeth, strongly chitinised, dark-brown in colour; the lacinia mobilis which, with the conjoined spine row, is capable of a slight mobility,[1] is divided into three teeth very similar to those of the outer dentate edge; on the *right mandible* the lacinia is rather more widely removed from the outer edge and is distinctly more slender, less strongly chitinised, paler in colour but retaining the three teeth which are minutely denticulated. The spine-row is strongly developed on the right mandible (fig. 14, *6r*), the toothed spines fewer and the anterior and posterior rows less widely separated. On both mandibles, a vertically set comb of shortly pinnate setae fills the gap between spine-row and molar. In the molars, too, of the opposite mandibles, there exist certain differences, that of the right being long and tapering, with obliquely truncated grinding face, sloping from the middle line outwardly and downwardly, and bearing one or two free setae.

The palp, however, is alike in both mandibles, and arises from a small knob-like elevation; the joints are stout, the proximal the shortest, the second twice as long, both cylindrical, the second bearing a terminal circlet of pectinate setae, but a single seta only on the proximal joint. The distal joint, intermediate in length, has a somewhat flattened, pyriform shape with the narrow end strongly curved, the distal two-thirds of its concave border fringed with setae, increasing in length distally and ending in three or four particularly long, curved setae with short pectinations along one edge. In the female, the first and second joints seem more setose.

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[1] Cannon & Manton (1927, p. 223) note of the *lacinia mobilis* and spine-row in *Hemimysis* that it is 'probably passively movable' with which statement my own observations on Phreatoicids are in accord.

The *lower lip* (fig. 14, *7*) is bi-lobed, the two elongate halves, gaping distally, are not divisible into inner and outer lobes; distally it is convex, well-chitinised, with sub-acute apex inclined a little mesially. The entire inner border is furnished with a continuous brush of curved setae which lengthen towards the apex. In this species (as in some other Amphisopine forms) the fringe includes a rank of setospines, difficult to make out. The convex outer border usually lacks setae terminally, but, with a short gap laterally, the fringe begins anew (here much less dense and composed of curved simple setae) and continues proximally along the remainder of the lobe, the setae attaining their greatest length at about the middle of the fringes. Towards its proximal end, the lateral border is straight or even slightly concave and bare of setae.

Maxillula (fig. 14, *8*). The inner endite is shorter and, apically, distinctly narrower than the outer. Its distal extremity is gently rounded, and, on both sides, the appendage bears seven stout setospines with two other very slender simple spines. These constitute a close-set fringe which occupies the entire distal border, but are most closely crowded near the mesial edge and actually spread onto the inner (mesial) border. The outer endite is stouter, its obliquely truncated distal end entirely occupied by the broad bases of a double row of strong curved spines, thirteen or fourteen in number, variously denticulated, finely or coarsely, on one or both edges; the usual small postero-mesial setospine is present opposite the second spine, counting from the inner border. Sub-apically, there are two feebly-plumed setae on the posterior face; both endites bear an obliquely-set fringe of fine setae on both inner and outer borders.

Of the *maxilla* (fig. 14, *9*) Glauert says (1924, p. 53) that it ' is proportionally shorter and stouter than in the other species of the genus [i.e., *Phreatoicus s.l.*] and the lobes are more curved '. While it is difficult to satisfy oneself concerning the comparative shortness of this appendage, it is necessary to discriminate between actual *length* and the forward extension of the endites in their natural position. Descriptions of the Peracaridan maxilla convey the impression that the proximal endite possesses a mesial *edge*. In the Phreatoicoidea, at least, it actually has a long, triangular and narrow concave mesial *surface*, which may vary greatly in width (antero-posterior measurement), the two edges of which converge to meet distally and are each armed distinctively. The anterior edge is fringed, in this species, with a close rank of short fine setae. Separated from this by the width of the mesial surface is a second ridge carrying a continuous series of long setae plainly showing a division into a short, stouter, basal section, and a distal, more slender finely-pinnate part. This is obviously the rank of filtratory setae of Cannon and Manton's descriptions (1929, p. 177); immediately posteriorly to these there is a row of widely spaced, slender, sparsely ciliated setospines, which spring submarginally from the posterior surface. At about one-fifth of the length of the endite from its apex, these last become coarsely pectinate on one side, retaining the setospine condition basally; these extend to and around the apex of the endite where they are very crowded, lying behind a fringe of slender setospines to constitute a double apical row; altogether there may be about twenty-five of them, some twenty of which are more or less ciliated. This proximal endite (the ' fixed inner lobe ' of Glauert's description) is stated to be ' much shorter than the two outer articulated members ' (1924, p. 53). In its natural position, its relations seem much the same as those of other Amphisopine forms. Its posterior face is clothed towards its apex with a fur of short setae, a condition closely comparable to that figured for *P. terricola*, *S. ambiguus*, and found, also, in *E. kershawi*. Of the two movable lobes which are interpreted the endites of the third segment, the outer is distinctly the wider, although appearing narrower in the figure; both

are, however, quite obliquely set and overlap considerably, the inner member appearing to be partly ensheathed by the outer, and both have practically the same shape, with rounded obliquely-truncate end and convex outer and almost straight inner borders. They are armed terminally with a comb-like series of from fifteen to twenty long curved denticulate spines which lessen in length towards the mesial border. Hereabouts, the base of the comb appears curved out of the plane, this doubtless permitting to each lobe a certain freedom of movement in the transverse plane. The external spine on both of these lobes is generally much stronger than the rest.

The *maxillipeds* (fig. 14, *10m*) are large and flattened. The broad but short coxa bears a wide-based epipodite and, in the female only, a large bi-lobed plate which projects stiffly backwards and slightly laterally from its mesial edge and is fringed with long, stiff, finely-ciliated setae, curled towards their ends. The basis, long, slender, and sub-rectangular, is about three times as long as wide, its mesial surface expanded at about the middle of its length into the endite, which is continued almost to the middle of the carpus, where its apex is armed with a dense tuft of assorted setae, passing dorsally, upon the distal half of the endite, into a series of brush setae of continually increasing length, twelve to fourteen in number, interspersed with simple setae. Upon the flattened ventro-mesial surface of this inner plate near its ventral edge are borne two or three strongly curved and minutely denticulate coupling hooks. The very short ischium has a tuft of setae arising from its distal end on both inner and outer angles and is followed by the merus, once and a half the length of the ischium, with its outer distal angle produced along the outer border of the carpus, and bearing three or four widely spaced, pectinate setae. Its inner distal angle is armed with a cluster of setae like those upon the corresponding angle of the ischium but longer and more numerous. The carpus appears irregularly four-sided, its outer side somewhat convexly curved; the mesial border is nearly twice the length of that of the merus and fringed with setae which pass onto the distal border, while the external border has one stout spiniform and pectinate seta which occupies the distal angle; the propod is smaller and sub-oval with an inner setal fringe and three setae on its lateral margin. The dactyl is much smaller but has a similar shape and a closely comparable arrangement of its setae. The epipodite has shared in the elongation of the basis and is a thin curved plate, convex ventrally. Its distal border reaches to the level of the middle of the merus while laterally it touches the post-mandibular border of the head. Upon the distal half of its mesial border, it is set obliquely with a fringe of short and slender setae. Concerning the plate which springs from the coxa (fig. 14, *10c*) in the female, it should be noted that, in females with incipient brood lamellae, this coxal lobe, though small, has a fringe of stiff curled setules, while in the anterior lobe of the immature oostegite on the gnathopod there is a scanty edging of setae. It will be recalled that structures similar to the coxal plate, but even better developed, have long been known in other Isopods, and according to Hansen are concerned in the aeration of the brood-pouch (whether by drawing water in, or by bailing it out, is not clear), a view with which Sheppard, who first called attention to these structures in the Phreatoicidae (1927, p. 86) is in entire agreement. While they may so function in other Isopoda, there is difficulty in accepting this explanation for members of this family. In the first place, they are very small (although larger, perhaps, in the Amphisopine forms than in the Phreatoicinae) and project ventrally in an obliquely mesio-lateral vertical plane, so that any current they would create would be almost negligible. Further, there has been found no marked musculature in connection with these lobes. Again, the anterior end of the brood-pouch is

practically closed by the anterior lobe of the gnathopod oostegites and these maxillipedal lobes, which are included, in life, within the pouch, would be likely to be constantly tangling. It is, however, probable that, in the practically quiescent state, the anterior oostegal plates may gape somewhat with any small movement of the leg, in which event these maxillipedal lobes with their interlocking setae could form a most efficient grid or strainer preventing the entrance of coarser particles or of small organisms which accidently or intentionally might otherwise succeed in reaching the brood-pouch.[1] Calman's suggestion (1909, p. 200) quoted by Sheppard, that these lobes are homologous with the oostegal lobes of the following appendages appears entirely probable. That explanation may perhaps be extended by the suggestion that we are dealing here (in this extremely ancient group) with modifications of the gnathobases once present on all the appendages (cf. Entomostraca and Trilobite). In the Syncarida, where there is no brood-pouch, gnathobasic structures still persist on the maxillipeds of the Anasipididae, and comparable lobes even longer, in the female, on the seventh leg of *Paranaspides* and on the fifth and sixth leg of the *Koonungidae*. In the Phreatoicidae we find these lobes on the maxillipeds present only in the female, but they are found as vestiges in the male of *Paramphisopus*, *Amphisopus*, and *Eophreatoicus*. In one species *(terricola)* which in so many ways seems primitive, we find, frequently, in the male, incipient oostegites as well. In the male, too, the genital appendage comes away, in dissection, with the coxa and might easily be a scroll-like modified plate of this series—which origin would account for the frequent appearance of this tube in the female, just as oostegites may be present in the male.[2] As regards the aeration of the brood pouch, the structure of the large oostegal plates suggests that these might well function in the supply of oxygen to the larvae (in a fashion analogous to that in which *Protopterus* is said to discharge oxygen to its nestlings through its highly vascularised fin filaments) that is, supposing the oxygen content of the current probably drawn through by the movement of the pleopods was insufficient for the respiration in the embryos.

In the Oniscoidea, there are paired sternal outgrowths (cotyledons) which project from the sternite of the anterior peraeon segments into the brood pouch and may serve as accessory organs for aeration.

The *peraeon and it appendages.* In his description of the peraeon segments of *A. palustris*, Glauert notes 'first segment . . . inferior margin, . . . second, third, and fourth segments . . . lower margin slightly excavate, . . . fifth, sixth, and seventh segments . . . lateral margins convex'. Reference to the *habitus* figure will make it clear that the lateral or pleural margins of all seven peraeon segments must be considered as more or less irregularly excavate, although, in the case of the fifth, sixth, and seventh particularly, the boundaries are indicated only by faint grooves, except at the anterior and posterior ends of the coxa where there exist short incisures. In the more anterior segments, the pleura have become produced downwardly in part into a lobe anterior to the coxa and partly hiding that joint, this lobe being angular, flattened or rounded, and, in every segment but the first, armed with from one to three spiniform setae. In females with incipient brood lamellae the postero-lateral part of second to fourth peraeon segments has a slight flare outwardly, suggestive of the condition which is so fully developed in *P. latipes*. In the male, the coxa has fused immovably with

(1) In an earlier paper (1926, p. 200) attention has been called to the fact that in this species, a small stalked Acinetarian which infests the animal makes its way into the brood-pouch and may be found on the newly-emerged larvae.

(2) Similar occurrence of these tubes is noted in females of *M. capensis;* but that there may be variably developed a real hermaphrodite condition is an explanation which must not be overlooked.

the overlying body-wall, although the outlines of the joints may still be made out by examination from the inner aspect; of the female, Sheppard has stated that in this species (as well as in *P. latipes*) the second, third, and fourth coxae *remain freely movable.* If this be a fact, about which the writer has some uncertainty, it is doubtless in relation to the large number of embryos and the consequent size of the brood-pouch and the need for greater freedom of the oostegites.

The *gnathopod* (fig. 15, *11*). The coxa is largely hidden by the anterior downward projection of the pleuron to the inner aspect of which it is fused; the basis has a small flattened expansion on its anterior border *about twice as long as wide,* armed with a spiniform setae and two or three finer setae on the rounded upper anterior angle; the posterior margin has but two or three widely-separated fine setae; ischium almost three-fourths the length of the basis, rounded and almost devoid of setae; merus short, antero-distal angle greatly produced, convex proximally with two spiniform setae, concave distally, one stout spiniform and several finer setae occupying the postero-distal angle. The carpus, which articulates only with the posterior part of the concave distal surface of the merus, forms a rather irregular, short, four-sided pyramid with well-rounded edges and deeply concave base, this cup-like hollow being anteriorly directed and receives the proximal end of the propod, thus permitting considerable freedom of movement to that joint. Along the posterior border of the carpus a few setae are scattered. The propod in the male (fig. 15, *11* ♂) is large and extremely thick, so that the closed hand appears as a sub-globose mass compressed postero-ventrally at the palmar edge. The dactyl slides partly past this edge and comes to rest against the mesial face. A fringe of short setae extends from near the infero-distal angle of the carpus along the ventral border of the propod and the slightly sinuous palm very nearly to the base of the dactyl, but at the rounded (posterior) palmar angle this is reinforced by a rank of stout, minutely-denticulate conoidal spinules of which six or seven are more strongly developed. The convex anterior border of the propod has but a half-dozen or so of widely separated setae; the dactyl is set, along its palmar edge, with short fine setae, has a short fringe dorsally, near it insertion, and several longer setae overhanging the unguis.

In the female, of the same size, the limb as a whole is more slightly built and distinctly shorter; the most notable difference, however (apart from the presence of an oostegite), is seen in the propod (fig. 15, *10* ♀), which is small, relatively feeble, and sub-triangular in outline; its anterior margin is convex, with a few fine setae; the posterior border meets the concave palm in a well-rounded angle, both edges being set with a continuous sparse fringe of setae or spines which are stoutest at the palmar angle. Antero-distally the propod is produced into a slight eminence upon which the dactyl has its insertion. This terminal joint is slightly curved with convex anterior and nearly straight posterior margins, the latter strongly denticulate for much of its length. Just proximal to the unguis is the usual tuft of setae, but a secondary unguis cannot be distinguished in either sex. In a fully-grown female the hand may be larger than that of a mature male.

The second, third, and fourth peraeopods, while all closely alike, exhibit certain differences progressively as they are traced posteriorly. The basis (less stout than in the gnathopod) lengthens and develops along its *anterior* margin a flattened plate which, in the fourth limb, has become quite noticeable.(1) The

(1) This expansion of the bases of the peraeopods of this anterior group by the development of a plate on the anterior surface of the otherwise rounded joint is probably a primitive condition. It is found in *E. kershawi* and is marked in the fossil *wianamattensis.* It is, however, not always obvious in the entire specimen, due to the fact that these limbs seem capable of considerable rotation and frequently present externally the narrower edge of the joint.

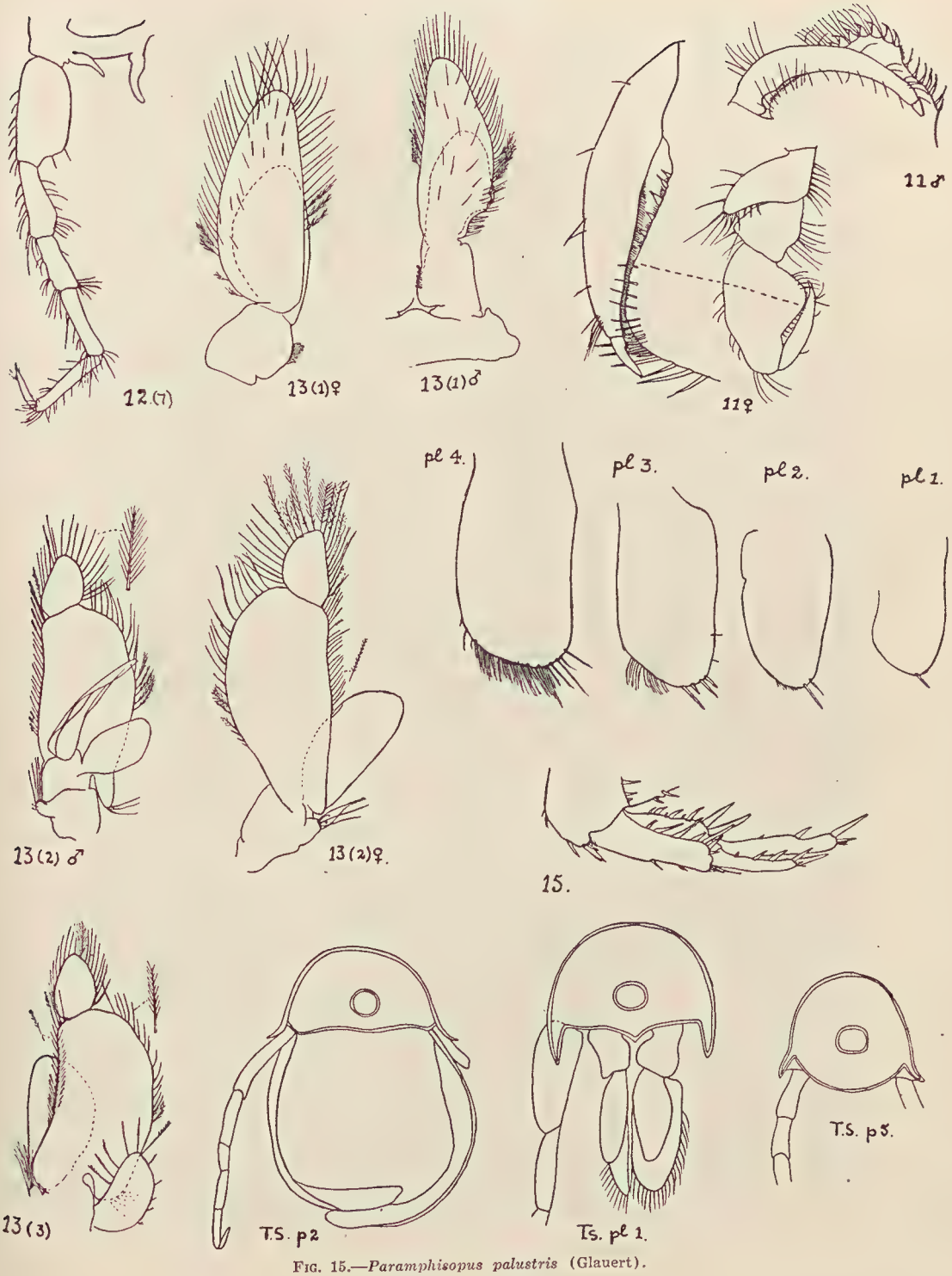

FIG. 15.—*Paramphisopus palustris* (Glauert).

ischium, relatively, is slightly shorter; the merus lengthens and its transverse expansion decreases. In all three of these peraeopods an almost rod-like carpus replaces the sub-pyramidal joint of the gnathopod and, in the fourth peraeopod, has become as long as the merus; the propod is cylindroidal, and the dactyl longer, slender, and almost straight. Its posterior border, set with fine setae, appears serrate and a distinct secondary unguis is present. In all of these peraeopods, the dactyl seems to move within paired flange-like terminal extensions of the propod, and is, probably, capable of being folded down quite extensively in sub-chelate fashion, but there is little suggestion of a palm upon the propod, nor, in the fourth, is there any modification of the appendage into a secondary sexual structure. Glauert states (1924, p. 49) that the female is held *only* by the powerful gnathopods of the male, in which respect the species of this genus differ from the great majority of Phreatoicoidea, so far as is known. These peraeopods of the anterior group are not very strongly setose. Upon the anterior border of all is a small cluster of spiniform setae near the proximal end of the basis, generally including one much stronger seta. Upon the fourth peraeopod, a similar seta (sometimes two), accompanied by five slighter setae, arm the anterior face of the ischium, while the anterior border of the merus has a setal arrangement agreeing with that upon the corresponding joint of the gnathopod; the antero-distal angle of the carpus has a small tuft of mixed, stout and slender, setae, while a group of two setae occupy the middle upper border of the propod and a cluster of fine, sub-terminal setae overhangs the unguis of the dactyl. Upon the inferior border of the basis and ischium are a few scattered fine setae, but upon merus, carpus, and propod there is a series of somewhat stouter spiniform setae fairly regularly spaced on each joint. The setal armature of second and third peraeopods does not differ materially from that of the fourth. In the female, these peraeopods are shorter and less stout than those of the male, but appear to be slightly more setose. The coxal joint of each bears, in the mature animal, a brood-plate which, when fully developed (fig. 15, *T.S. p.2*), reaches a length little less (and in some cases much greater) than that of the related peraeopod. It is markedly pigmented in its proximal (exposed) part, the overlapping portions being without chromatophores. Each widens distally and may be slightly lobed, that borne upon the gnathopod being smallest but very *distinctly bi-lobed*, the two lobes being disposed almost at right angles, the anterior lying transversely to ensheathe the base of the maxilliped. In the stage preceding the ovigerous condition, the lamellae are narrow, calcified, and strap-like and lie adpressed to the sternite, overlapping slightly in the middle line.

The three next succeeding peraeopods, in both sexes, form a posterior series. They are backwardly directed and, due to an elongation in every joint, are seen to increase progressively in length as they are traced backwards. In *P. palustris*, they are characterized by an expansion of the basis less notable than in *Amphisopus* spp. This joint consists of the usual flattened cylindroidal piece, but, on its external face, it is produced backwardly into a broad thin flange which, beginning at the proximal end, widens rapidly to reach its maximum in the case of the fifth peraeopod at about the first-fourth of the length of the segment. Here the joint is about two-thirds as broad as long and maintains this width nearly to the distal end of the segment, where it diminishes very abruptly at the 'inferior notch' of Glauert's description (1924, p. 55). Owing to the slightly oblique articulation of these limbs, the more anterior can slide freely upon (external to) the more posterior (Nicholls, 1924, pl. 1, fig. 2), and all can be upturned considerably, the arrangement of the broadened part of the plate being such as to

permit of unhampered movement of the proximal joints.[1] In the natural position for walking or swimming, these three plates constitute a very considerable anterior expansion of the natatory and respiratory channel provided by the pleura of the pleon region, producing it forward, in the female, to the posterior end of the brood-pouch. The observed activity of Amphisopine species, as contrasted with Geoffrey Smith's observations (1909, p. 71) made upon some Tasmanian Phreatoicids, may well be related to this structural difference, for in the greater number of Tasmanian species these bases are either but little or not at all expanded, the pleopods may be presumed less efficient as swimming organs (the animal would appear to move almost wholly by crawling), losing the natatory function, while retaining the respiratory. The remaining, more distal, joints of these peraepods are rounded and tend to enlarge slightly towards their distal ends; carpus and propod are sub-equal, more slender and much longer than the corresponding joints of the limbs of the anterior series; the dactyl, also, is elongated.

The anterior border of the bases is set with spinelets, its posterior border provided with fine setules only. On the other joints, setae are presented almost wholly by the larger spiniform type. In the dactyl, the secondary unguis is little more than a slender spinule; the outer terminal cluster is reduced to a couple or even a single seta. This setation is modified in the seventh peraeopod (fig. 15, *12(7)*), and the basis differs notably from that of *Amphisopus* in the setal armature.

In the *pleon*, the notable feature is the considerable development of the pleura. The first four segments are, as already noted, sub-equal and rather shorter than the peraeon segments. They are, however, quite unlike in the degree to which the pleura are downwardly produced, deepening progressively from before backwards. The hinder margins of pleuron and segment meet in a gently-rounded curve, the pleura being longer (antero-posterior measurement) than their related segments. Of necessity, therefore, they overlap externally (from before backwards) to a varying extent dependent on the straightness or the curvature of the body, the maximum overlap occurring, of course, when the animal is completely curled up. The first is shallowest, extending distally to *two-thirds* of the depth of the basis of the seventh peraepod. It widens for nearly half its length, then narrows to a rounded apex, armed sub-terminally on its hinder border with a single slightly curved short *spiniform* seta. The second, third, and fourth pleura increase progressively in length, have a gently convex inferior margin provided with stiff setae or setules on the antero-distal angle, increasing in number from two to ten. On third and fourth there is a series of long setae postero-distally. The fourth and fifth have a fringe of about ten spiniform setae, spaced along the inferior margin, mingled with numerous delicate hair-like setae; the posterior border of the fifth has quite a large re-entrant angle where segment and pleuron meet. In all, the posterior margin is entirely free from setae, differing conspicuously in this from *Amphisopus* spp. Deep as are the pleura, they fail, nevertheless, to conceal entirely the pleopoda, and in life the lower ends of these may be seen waving well below the ventral edges of the pleura.

The *pleopods*. These differ relatively little in length (dorsi-ventral measurement), the first pair being perhaps very slightly shorter than the second or third, and sub-equal to fourth or fifth. The length of the first pair is, however, made up materially by the well-developed sympodite which is, both relatively and actually,

[1] In the Amphipoda, the mobility here in a dorsi-ventral plane is probably increased still further by the freedom of the plate-like coxae (epimera). In Phreatoicids, the pleopoda have perhaps a lessened importance as swimming organs, but the existence of the peraeonal extension forwards of the pleon pleural wall should make the current created by the pleopods more effective in the flushing of the brood-pouch.

longer than in succeeding limbs. In width, there is a distinct and progressive increase from the first pair backwards.[1] In every case but the first, the pleopod shows the sympodite as a somewhat flattened conoidal mass, bearing distally two unequal lamellae, of which the exopodite is variably pigmented, and the endopodite has only about two-thirds the length of related exopodite. The exopodites are notably setose, the setae being for the most part plumose, the fringe generally more or less wanting latero-proximally in the most posterior of these appendages. Here, the lamellae reach their maximum width and practically extend, completely from side to side of the respiratory archway. The endopodites, invariably without setae, are narrower than the related exopodite, but tend to show some increase in size progressively from the second to the fifth.

First pleopod. The sympodite is roughly quadrangular, longer than wide, and narrowing distally, although this is masked by the development anteriorly of a convex mesial flange-like portion set with a complex coupling-hook apparatus. These hooks are numerous and arranged in an unequal double row on the two appendages; that, on the right, may be accompanied by one long flexible seta. The hooked part of the structure has a shape recalling the fluke of an anchor. The endopodite is a rounded oval lobe (not distally emarginate as in *M. capensis* or *A. lintoni*) springing from the distal mesial border of the sympodite, about two-thirds of the length of the exopodite. The latter consists of a narrow, undivided lamella, sub-acute and bordered almost continuously with setae, except for a quite short stretch proximally. Upon the mesial border the setae are finely feathered, and a number of simple setae (some almost spiniform) spring sub-marginally from the anterior face of the lamella. In the male (fig. 15, *13(1)* ♂) the proximo-lateral portion of this lobe is strongly excavated.

Second pleopod. The sympodite is shorter relatively and narrows more sharply towards its distal end. From the distal end of its mesial edge arises a well-marked lobe, its rounded apex set with a group of long, stiff setae which interlock with those of the opposite cluster. Intermingled with these setae are a few (two or three) coupling hooks. The exopodite is longer and broader than in the first pleopod and is obliquely divided distally to form in a small articulated second lobe. On its lateral border the exopodite is produced proximally into a lobe reaching dorsally almost to the sternite. The few setae borne by this lobe are simple, while those on the mesial border of the exopodite are pectinate, the lateral and terminal setae being plumose. Sub-marginal setae are few and very fine. In the female, the endopodite resembles that of the other appendages, being an oval lamella extending distally for about two-thirds of the length of the basal exopoditic lobe. In the male, the endopodite is divided transversely into a proximal joint, thickened and muscular, and a distal portion subdivided lengthwise into inner penial stylet and outer respiratory lamella,[2] which is smaller than the endopodite of the corresponding limb in the female. The stylet is a stout, curved rod, tapering markedly to its extremity, devoid of setae, and exceeds the level of the distal end of the related lamella. It is irregularly scroll-like, forming an incomplete tube, the edges of the groove set with a close fringe of oblique setae.

Third, fourth, and fifth pleopods. These differ from the foregoing not only in their proportions, but also in the retention of an epipodite. This springs from

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(1) The powerful muscle related to the pleopod seems to be attached to the inner aspect of the pleural expansion at the point of junction of this with the tergum.

(2) Said by Calman (1909, p. 206) to represent a distal endopoditic joint in some Isopods. In *Phreatoicopsis* and *M. capensis* a small swelling upon inner border of endopodite occurs on third pleopod at the level of the penial stylet of second pleopod in the male.

the proximal outer border of the sympodite. In shape, it is a bent oval or subreniform, articulating with the sympodite by but a narrow base. It is fringed with long setae which appear simple, but are actually finely feathered apically. On the mesial border of the sympodite there is a small setose lobe, differing in no essential from that described as present on the second pleopod, excepting for the absence of coupling hooks.

As Chilton has pointed out, the division of the exopodite of the pleopoda (except the first) into two distinct joints is not common in the Isopoda. In some specimens, the bases of the long plumose setae *appear to be continued proximally toward the axis of the joint.* While this may be only an artifact due to some protoplasmic retraction it may, nevertheless, well be that these lamellar structures (known only in Isopoda and much more nearly linear in Tanaidacea) have arisen from multi-jointed biramous appendages of the Syncaridan type (still found in the Mysidacea and Amphipoda among the Peracarida), by the flattening of the axial joints and the confluence of the adjacent bases of plumose setae and further confluence of the joints of which only a terminal group has retained independence (and that only in the Phreatoicidae), even this being lost in the first pleopod which has already attained the condition of most Isopoda. The modification has gone further in the endopodite, in which only in the second pleopod is there any indication of a second joint, and all the unfused setal fringe is lost, except in *Mesamphisopus*, where both lamellae are setose and plumose, and in *Hypsimetopus* and in a few New Zealand species, where this condition is still preserved in the first pleopod. This suggestion of the more nearly primitive condition of the Phreatoicid pleopods (amongst the Isopoda) is further supported by partial retention of a segmented condition of the sympodite (perhaps the retention of traces of pre-coxae) and the persistence, also, of what are possibly gnathobasic lobes upon these abdominal appendages. If this interpretation be correct, then it is of further interest to note that, although the distal lobe of the exopodite has lost its independence in the first pleopod, that limb, nevertheless, retains in *Amphisopus*, *Eophreatoicus*, and *Phreatoicopsis*, and some New Zealand species, the long sub-triangular shape consequent upon the complete fusion of the proximal and distal lobes, whereas in other Phreatoicids modification has continued till in some genera (e.g., *P. typicus*) this ramus has taken on almost the shape found in the Asellota. It is, of course, possible that evolution has not followed the same lines in these two types and that in *P. typicus*, the Asellota, and others the rounded outline in the first pleopod is the consequence of the actual loss of a distal lobe,[1] instead of merely its fusion with the proximal exopodite lobe.

The *tailpiece.* This has a profile which suggests a sub-conical or helmet-shaped body; actually, it consists of the median dorsal or axial sub-cylindrical part downwardly produced on either side into pleural extensions, so that seen from behind (or in transverse section) it is somewhat horseshoe-shaped. The attachment of the uropods appears to be ventro-mesial to the distal edge of this pleuron, and from the dorso-posterior angle of this insertion a spinous ridge, usually armed with three or four spiniform setae, runs upwards upon the tailpiece, which ridge has been interpreted (Stebbing, 1893, Sheppard, 1927, Nicholls, 1926) as marking the sutural line between sixth pleon segment and telson. In this view, all that part of the tailpiece that lies postero-dorsally would seem to be telson. If that be the case, we have, in this family, a broad telson whose pleura are bent downwardly on either side into an arched shape such as is not apparently met with

(1) Not infrequently, in life, a terminal lobe has been lost from the hinder pleopods and the mutilated piece is then often strikingly like the shape of these appendages in *typicus*.

in any other Malacostraca. Seen from the side (fig. 14, *3s*) the tailpiece presents, dorsally, a gently convex surface, dipping rather more steeply near the posterior end, the actual termination being slightly tip-tilted. This terminal piece projects very slightly, is convex above from side to side, while its posterior margin is also strongly convex. From the dorsal edge of the projection spring three or four stout spiniform setae, cilia-tipped and intermixed with a few finer setae. Laterally, on either side from this projection, the pleura flare outwardly and downwardly. This outward curvature, which is most pronounced dorsally, is little evident. so that a very strong spine crowning a conical prominence (which marks the dorso-lateral angle) appears to spring almost from beneath the terminal projection. The spine is usually accompanied by a spiniform seta and one or two finer setae, while anterior to it, and at the same level, is a smaller sub-marginal spine, difficult to make out against its background. From the dorso-lateral spined eminence, the pleural margin turns much more definitely downwards, though still curving slightly laterally. The edge appears slightly serrated, the serrations lodging in turn a spiniform seta, a large spine, and two progressively smaller spines—all of which are uniciliate. It is from the postero-inferior angle that there extends obliquely a ventral ridge marking the internal line of attachment of the peduncle of the uropod. From its lowermost point, the inferior margin of the tailpiece is nearly horizontal, then sweeps forwardly sharply dorsally as the anterior margin of the piece. The postero-inferior angle is occupied by a very stout, *simple* spine and is preceded by three or four curved spiniform setae and a spinule, all approximately equidistant. The upper half of the anterior margin which, in some species, may be sparsely fringed with fine setae, is bare in *palustris*.

The *uropod* (fig. 15, *15*) consists of a stout wedge-shaped peduncle, which in lateral view appears sub-triangular, being deepest distally. Its dorsal surface is concave and its inner margin considerably higher than the outer. Upon this inner border are one or two stout spiniform setae, interspersed with spinules; distally the truncated edge bears three stout spines, increasing progressively in size. The outer margin is armed in a somewhat similar way, but the spines and setae not so numerous nor so strongly developed; its narrow ventral border appears unarmed, but actually bears clusters of setules varying from two to five in number, sometimes very fine and usually quite inconspicuous. The two rami are slender and sub-cylindrical, the inner as long as, or longer, than the peduncle, the outer distinctly shorter; beneath their insertion is a stout, curved, simple spine, and it may be accompanied by a setule or spinule. Dorsally, the inner ramus is slightly flattened (cf. *Mesamphisopus*), its borders armed at fairly regular intervals with three paired spines, its end truncated, bearing a long curved, and rather slender spine supported by a second spine and supplemented by one or more spinules or setae. The outer ramus is more slender, has upon its outer border two unpaired spines and its truncated apex is similarly armed with two long, curved and slender spines of quite unequal length. As in the inner ramus, the apical spines may be associated with one or more slender spinules. Usually, these limbs are more spinose in the female than in the male (cf. Chilton, 1894, pp. 260 and 262).

Colour. ' Dark olive brown, darkest on the dorsal region, which is separated on the peraeon and pleon from the somewhat paler margin by a light crescentic marking on each of the segments, head marbled, flattened bases, and ischium of peraeopoda five, six, and seven with pale blotches, mottling on the other joints of the legs '. (Glauert, 1924, p. 51.)

Size. Male 17 mm.; female 15 mm. (ovigerous specimens may have about 50 eggs or embryos in the brood-pounch).

Occurrence. Type locality 'Dog Swamp', Smith's Lake, North Perth; in numerous coastal swamps and shallow lakes in the immediate vicinity of Perth, e.g., at Wanneroo, Claremont, Bassendean, Guildford, Welshpool, etc. Nearly all these swamps are liable to dry out in summer, so that some specimens must presumably survive the summer buried in mud, as Barnard has shown to be the case in some *Mesamphisopus* species, and as is almost certainly the case in *P. montanus*, n. sp.

There is a fair range of variability in specimens from these different localities and it seems probable that at least those from Guildford will require to be separated as a new variety. That from Pinjarra, some fifty odd miles to the south of Perth, is perhaps still more distinct and is described below as a variety '*fairbridgei*'.

Paramphisopus palustris var. **fairbridgei**, var. n.

(Fig. 16)

This small form differs from the typical condition in the following characters:—

The *body*, as seen in dorsal view, appears almost parallel-sided in the male, but tapers markedly in the female, the fourth peraeon segment having the greatest width. Actually the animal is markedly sub-depressed.

The *head* (fig. 16, *2s*) shows the sub-ocular incisure rather better developed, and, behind, is overlapped by the first peraeon segment to a lesser extent. The *antennule* is relatively a little shorter, and there are minor differences in the proportions of the peduncular joints of *antenna*, the fourth joint being distinctly shorter; there are but twenty joints in the flagellum; the whole appendage is less setose. The eye is relatively large, but with fewer (thirty to forty) ocelli.

The coxa of the *gnathopod* seems less forwardly displaced and the hand (fig. 16, *11*) differs in the shape and armature of the palm. In the hinder *peraeopods* there are small differences; in the seventh (fig. 16, *12(7)*), for example, in setation as well as in the shape of the ischium and the relative proportions of ischium, merus, and carpus.

In the *pleopods* the latero-proximal excavation on the exopodite of the male is less pronounced, while the *uropod* (fig. 16, *15*) shows differences in the armature of both peduncle and inner ramus, as well as in the relative length of the rami and terminal spines.

The anal opening is disposed nearly vertically instead of horizontally as in *palustris*.

In the size of the brood this variety is nearly intermediate between the typical form and *montanus*, there being apparently a maximum of about 32, which is large for so small a species. This may account for the exceptional size of the brood lamella and the markedly depressed condition of the anterior peraeon in the female.

In *colour* this form is practically indistinguishable from *palustris*, but the size of the largest does not exceed 12 mm. It was first taken by the writer in the winter of 1924, in swampy ground and nearby drains on the Fairbridge Farm, W.A. Later (1928) it was collected at Pinjarra some three miles to the south, in ditches emptying into the Murray River, but this area has since been extensively drained and the Phreatoicid is now rarely found.

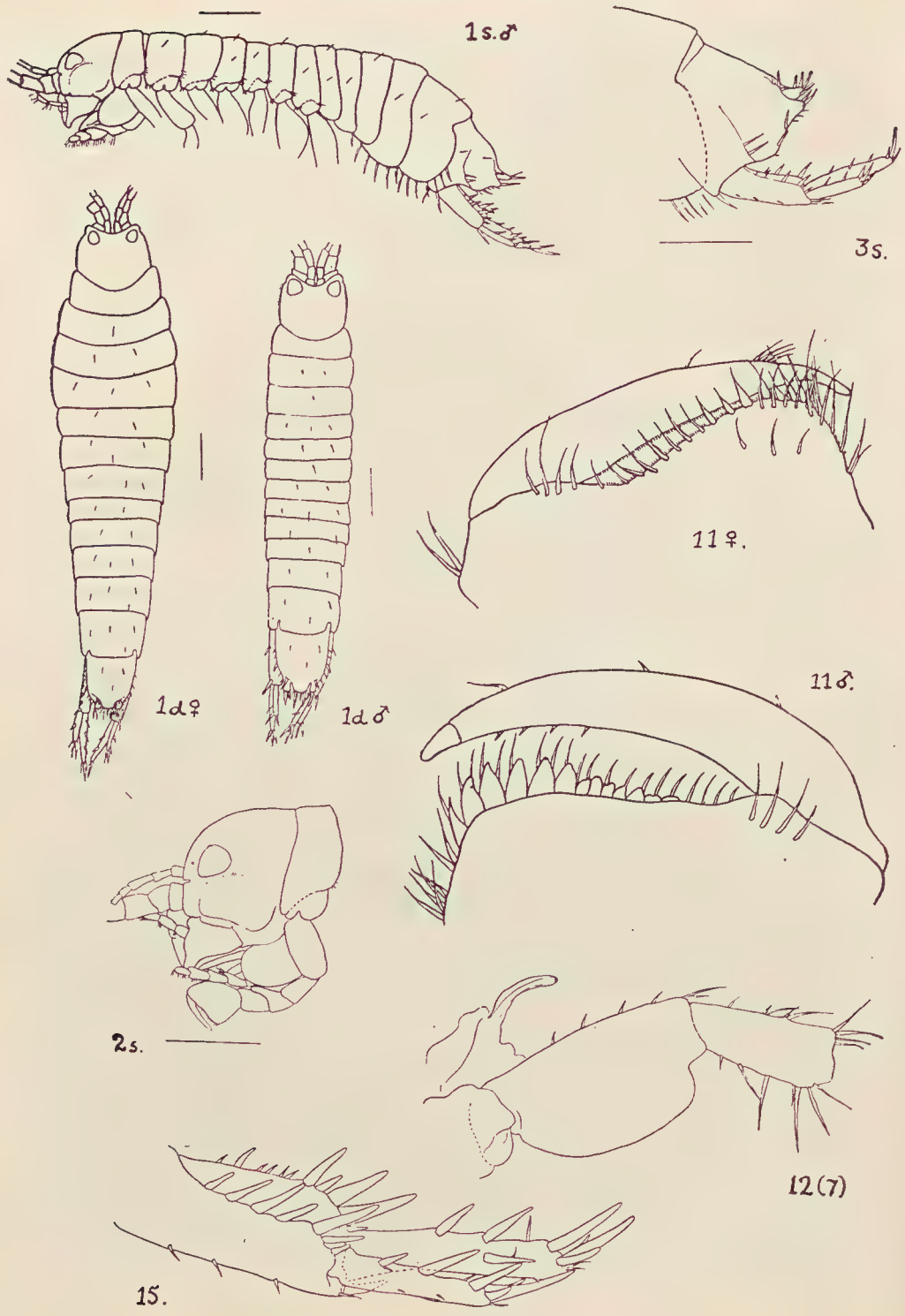


FIG. 16.—*Paramphisopus palustris* var. *fairbridgei*, var. n.

Paramphisopus montanus, sp. n.

(Fig. 17)

A small species, superficially very like *palustris*; body smooth, with sparse setae which are short and fine. Head as long as (or perhaps longer than) combined length of first and second peraeon segments; eyes with from fifty to sixty ocelli; first peraeon segment about two-thirds length of the second in female, in the male sub-equal; second, third, and fourth sub-equal and longer than the fifth, sixth, and seventh; pleon moderately deep and longer than the peraeon, the ratio of length of pleon to that of cephalo-peraeon being as 85 : 100; the first three segments are sub-equal in the female; the male shows the first pleon segment shortest, and second, third, and fourth sub-equal; the fifth segment in the male scarcely shorter than the tailpiece, which is as long as the combined length of the first and second peraeon segments, but narrows somewhat sharply posteriorly; telson gently convex, but more deeply notched on either side of the median projection than is *palustris*, its pleural portion not strongly developed and with but few spines.

Antennule barely as long as the peduncle of the antenna, first joint little longer than broad, second joint longer than first, flagellum with joints somewhat elongate (eight in the male; seven in the female); olfactory cylinders on at least terminal four articles.

Antenna slender, about two-thirds of length of body, flagellum with about twenty-three joints. Upper lip lacks the lateral brush of setae and the palp of mandible is less setose than in *palustris*; epipodite of maxilliped has the mesial border fringed abundantly with long setae. Gnathopod in the male less massive than that of *palustris*, anterior border less convex, posterior border more rounded; in the female, the propod is triangular and the palm straight. In a specimen nearly 8 mm. long, the brood-pouch contained but six or seven embryos (in the coastal species, the number usually exceeds fifty).

The peraeon appendages slightly or not at all pigmented, the bases of second, third, and fourth peraeopods distinctly expanded; of fifth, sixth, and seventh, relatively less developed than in *palustris*, and less setose. The pleuron of first pleon segment narrow and rounded; all pleura in pleon fringed with long setae. Pleopoda unpigmented; sympodite of first pleopod has well-developed coupling plate bearing hooklets, the endopodite is short, little longer than the sympodite and is narrow and sub-acute. The exopodite of the second pleopod bears thirteen plumose setae on the lateral border of proximal lobe; endopodite and penial stylet are of equal length and reach almost, or quite, to the base of distal exopoditic lobe, coupling lobe bears but two to three spiniform setae and two coupling hooks. The succeeding pleopods differ little from those of *palustris*, except that there are small oval epipodites and that coupling lobes bear but two or three spiniform setae and are without coupling hooks.

The *uropods* (fig. 17, *15*) are of but moderate length, peduncle not reaching to the end of the telson and armed with numerous long and very slender spines, the terminal pair of the inner ramus being two-thirds the length of the outer ramus.

Colour. Pale, scattered black chromatophores on a light background. In spirit, the yellowed muscles may be seen through the exo-skeleton and the specimens appear a pale yellowish-grey. In life, translucent.

Length. Male nearly 10 mm.; female with brood lamellae (but not ovigerous) nearly 9 mm.

Locality. 'The Lakes', just off the York Road, about thirty-two miles due east of Perth. W.A. This sheet of reed-covered water, which lies upon the summit of the

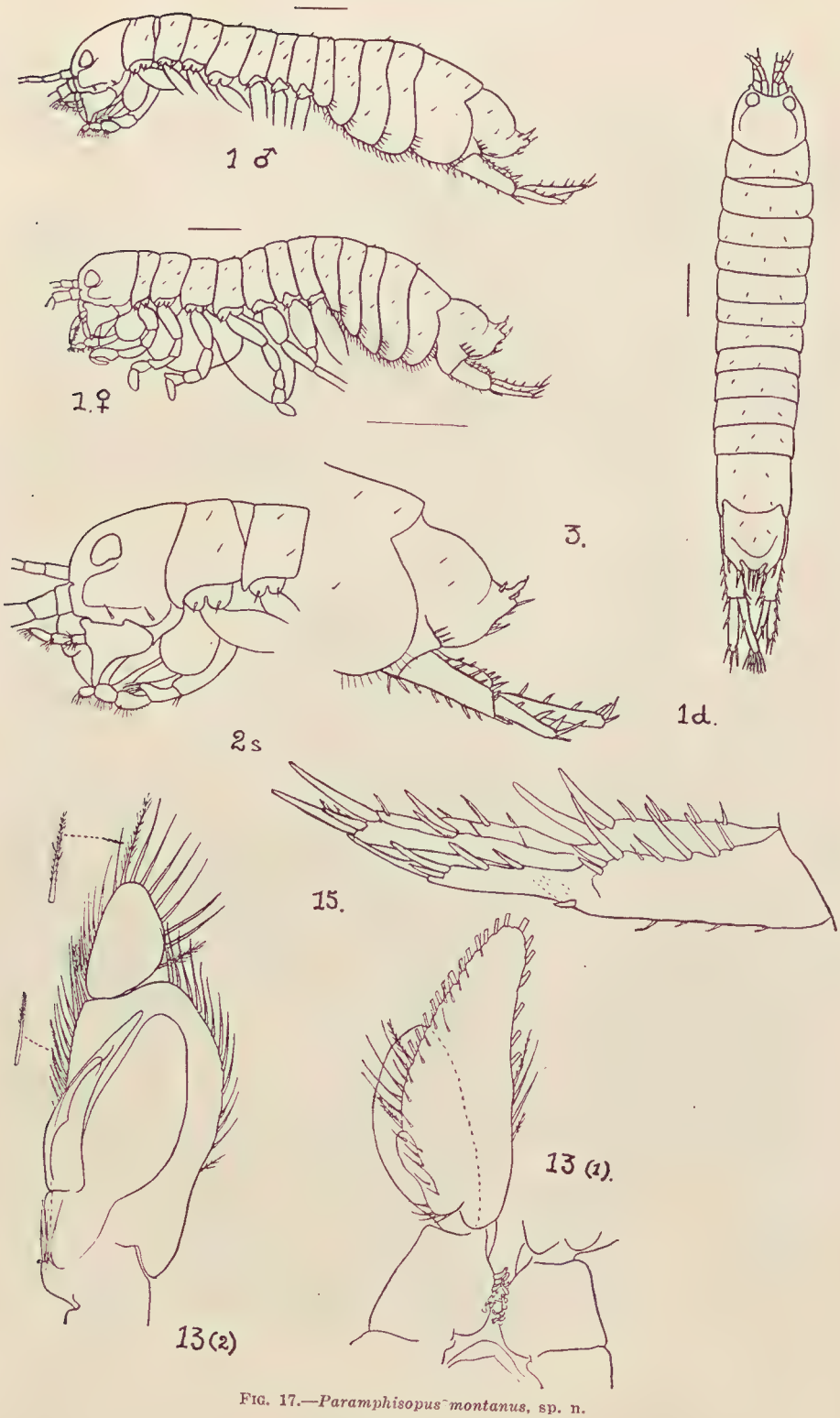


FIG. 17.—*Paramphisopus montanus*, sp. n.

Darling Range at an altitude of less than 1000 feet, practically dries out every summer. The species was first taken in 1926; since then, secured on several occasions. On the latest of these (1/6/1939) a large number was collected.

Co-types are lodged in the collection of the Museum, Perth, W.A.

The description given above is little more than an enumeration of the details in which this species differs from *P. palustris*, which, superficially, it seemed to resemble so closely that it was originally regarded as being a variety (1926, p. 183). In the smallness of the number of the brood there is, however, a character found in no other Western Australian Phreatoicid, except the still smaller and wholly subterranean *Hyperoedesipus*; the greater elongation of the pleon, the relatively greater size of the first peraeon segment, the reduction in the number of ocelli and in the length and number of joints in the antennae, as well as the diminished pigmentation, are characters probably all acquired in adaptation to life more nearly cryptozoic than that led by any other of the known Amphisopine surface-living species. This habit may perhaps be a consequence of the annual recurrence, in the case of *P. montanus*, of a nearly complete drying out of its swampy lake. The lake was dry, when first visited, the specimens actually being taken in thin mud at the bottom of depressions made by the hooves of cattle, where only a film of water still lingered.

Amphisopus Nicholls

Nicholls, G. E., 1926, p. 182 *(Amphisopus)*.

Head with short sub-ocular incisure, without cervical groove; eyes large and prominent. *Peraeon* but slightly compressed; *posterior margin* of some peraeon and of all pleon segments fringed with setae; tailpiece with a short median and longer lateral ridges; telson not projecting, emarginate; *antennule* distinctly longer than peduncle of antenna, with numerous short joints; olfactory cylinders on last four to six joints; *gnathopod* of male and female alike in shape, but fourth peraeopod of male sexually differentiated as a modified sub-chelate structure, the carpus being involved as well as the more distal joints; coxae of all peraeopods immovable in both sexes, but the suture defining coxa of the fifth, sixth, and seventh peraeopods persistent, bases strongly expanded; both first and second pleopods modified in male; sympodite of first and second pleopods with numerous coupling hooks and without entangling setae; one stout and two more slender toothed spines beneath insertion of rami of uropod, base of inner ramus twisted as in *Mesamphisopus*.

This definition differs in several details from that originally proposed. This is due, in part, to the exclusion of two species and the addition of one new Western Australian form, as well as to the discovery of a number of characters previously overlooked.

Genotype. *Amphisopus lintoni* (Nicholls).

Amphisopus lintoni (Nicholls)

(Figs 18, 19)

Nicholls, 1926, p. 182; 1924, p. 93, pls. 8, 9 *(Phreatoicus lintoni)*.
Sheppard, 1927, p. 116 *(Phreatomerus lintoni)*.
Sheard, 1936, p. 473.

Body (fig. 18, *1*) moderately stout, surface smooth with few scattered setae; *head* short, scarcely longer than second peraeon segment; eye large, sub-reniform,

with numerous facets (150 or more); *peraeon* sub-cylindrical, segments deeper than long, second, third, and fourth nearly sub-equal, fifth, sixth, and seventh successively shorter, seventh nearly as short as the first; pleura of segments one to four scarcely downwardly produced, only partially concealing the coxae; *pleon* moderately long, having with the telson a length almost three-fourths that of combined

FIG. 18.—*Amphisopus lintoni* (Nicholls).

cephalon and peraeon, first to fourth segments sub-equal in length, fifth segment meeting its pleuron behind in a deep notch, as long as the combined length of the third and fourth; tailpiece (fig. 18, *3*) large; median projection lacking, the transverse postero-dorsal border slightly arched, with shallow rounded emargination, the margin of telsonic pleura deeply notched and raised into three well-marked paired prominences, each crowned by a stout movable spine. The suture between sixth pleon segment and telson is well developed and at its posterior end bears several stout and movable spines. Anterior to the uropod, the pleuron of the sixth segment has its margin armed with from four to six spines and spinules.

Antennule (fig. 18, *4*) longer, relatively, than in any other Phreatoicid, flagellum extending to sixth joint of flagellum of *antenna*, with as many as eighteen short joints, which widen distally. The *antenna* equals the combined length of the head and the first six peraeon segments, or rather more than twice the length of the antennule, peduncle with first joint very short, second and third stout and sub-equal, fourth nearly as long as first and second combined, the more slender fifth almost equalling the combined length of third and fourth; the flagellum, once and a half as long as the peduncle, may have thirty or more joints, the first being short. The fur-like covering of fine setae found in *palustris* is wanting in this species.

The mouth parts differ in many details from those of *palustris*. The labrum (fig. 18, *5*) broader than deep, its ventral edge densely fringed with very short setae, while across its anterior aspect is an interrupted rank of long setae; *mandibles* (fig. 18, *6*) with palp relatively short and stout, second joint half as long again as the third and greatly widened; all joints setose, many setae pectinate, the rank on the third joint stretching along most of the length. On the right mandible, both the principal cutting edge and that on lacinia mobilis bear four teeth; those on the lacinia being minutely denticulate; a row of plumose setae lies dorsal to the spine row and one or two free setae arise from the molar surface; *lower lip* (fig. 18, *7*) shows a relatively great development of the latero-distal tuft of setae and a number of setospines occur on the mesial border. The inner endite of the *maxillula* (fig. 4B) is widened distally, its rounded end with from seven to nine setospines; outer endite, with one small setospine near the inner end of the row of teeth, and two sub-terminal plumose setae on the posterior face of the endite.

Maxilla (fig. 18, *9la*), examined from in front, the proximal endite appears sub-triangular, very wide at its base; it is scarcely divided into proximal and distal parts; the mesial surface narrow, the entire length of its anterior edge occupied by the usual continuous row of filter setae which reaches the end of the proximal part of the endite and passes onto its anterior surface. Just proximal to these filter setae there is a short fringe of simple setae, and upon the anterior face of the endite, nearly level with these, is a small tuft of similar setae, but the continuous line of setae anterior to the filter setae, present in some species, is wanting in *lintoni*. The posterior ridge (fig. 18, *9rp*) bounding the mesial surface is armed by stout, widely-spaced, biting setae, varying in number from nine to fourteen, and extending to the inner edge of the apex. Parallel to these, on the posterior face of the endite is a shorter fringe of simple setae. These in the distal part of the endite spread out and cover much of this surface—they are hidden from view in the figure by the inner of the two distal endites. The outer edge of the inner endite is fringed with long, simple setae. The inner of the two distal endites is short and narrow, its very obliquely truncated apex bearing a single close-set series of biting setae. The outer endite is broader and similarly armed. Its lateral border has a distal fringe of setules, and proximally, from the bases

of the second and third segments, arises a whorl of long setae. Still more proximally is another short fringe of setules.

Maxilliped (fig. 19, *10*). This is remarkable, in the male, for the presence of a stout setose lobe on the coxa, resembling that of the immature female of other species, and for the development on the postero-mesial surface of ischium, merus, and carpus of a pilose area thickly crowded with setules. The distal end of the basis shows a trace only of this condition, but ventrally it bears a small group of plumose setae; on the endite of the basis, the fringe of brush setae stretches for two-thirds of the length of the dorsal edge of the endite and passes apically into a series of simple setae which are continued along the ventral edge in a line of biting setae; the distal border of the ischium has a fringe of plumose setae; the merus is produced almost to the distal end of the carpus, much of its distal margin bearing an edging of simple setae; the dactyl is practically devoid of setae along its outer margin. In the ovigerous female, the coxal lobe is large and bears a number of short plumose setae distally; more proximally the setae are curved and may bear one or two barbs apically. The epipodite is large, sub-circular, with a mesial border of setae and a few apical setae.

As compared with species of other genera, the *peraeopods* are relatively short; in all, the coxae are fused with their related segments in both sexes; the hand of the gnathopod (fig. 19, *11*), which does not differ greatly in shape in the two sexes, attains, however, a much larger size in the female, and is more widened basally. It has the propod sub-triangular, the palm meeting the posterior margin in a rounded prominence which is markedly setose and more pronounced in the female, the distal portion of the palm being concave, the dactyl long and stout. The dactyl has a large sub-terminal spine in both sexes, but otherwise the armature of the dactyl differs markedly, being denticulate in the female and armed with close-set setae in the male. In the male, moreover, there is found a pilosity of the hinder surface of ischium, merus, and carpus which is even more pronounced than in the maxilliped. A similar development is found in the male on second, third, and fourth peraeopods; but in the female this condition is not developed, the second, third, and fourth being much as in *palustris*. In the male, the fourth peraeopod (fig. 19, *12(4)*) is modified probably to a greater degree than in any other genus of Phreatoicoidea, the carpus, as well as propod and dactyl, being involved in the clasp; the ischium and merus are expanded, the latter strongly (approaching the condition of these joints in *Eophreatoicus*), the carpus also is widened, but the propod is curved and narrow and rounded apically. The dactyl, which widens distally, projects from the *anterior border* of the propod and acts, with that joint, as a single curved piece, folding against the strongly setose posterior border of the carpus. A tiny spinule represents the vestige of the secondary unguis.

The coxal joints of fifth, sixth, and seventh peraeopods are visible externally, a definite groove indicating the suture with the pleuron of the related segments; they have become flattened plates which have taken on the colouring and marking of the adjacent pleura; the bases are more strongly expanded than in *palustris*, but unarmed anteriorly; the succeeding joints have strong spiniform setae, occurring in tufts and more numerous than in the corresponding appendages of *P. palustris*, while the posterior border of the joints is produced into strong spines which may be very conspicuous.

The male appendage usually comes away with the seventh peraeopod if the coxal joint is also detached; it differs little from that of *palustris*.

The ventral margin of the first pleon segment is rounded, the anterior part of the curve with about six setae which become spiniform, while the more posterior part of the margin, in this and the following pleura, is set with short hair-like

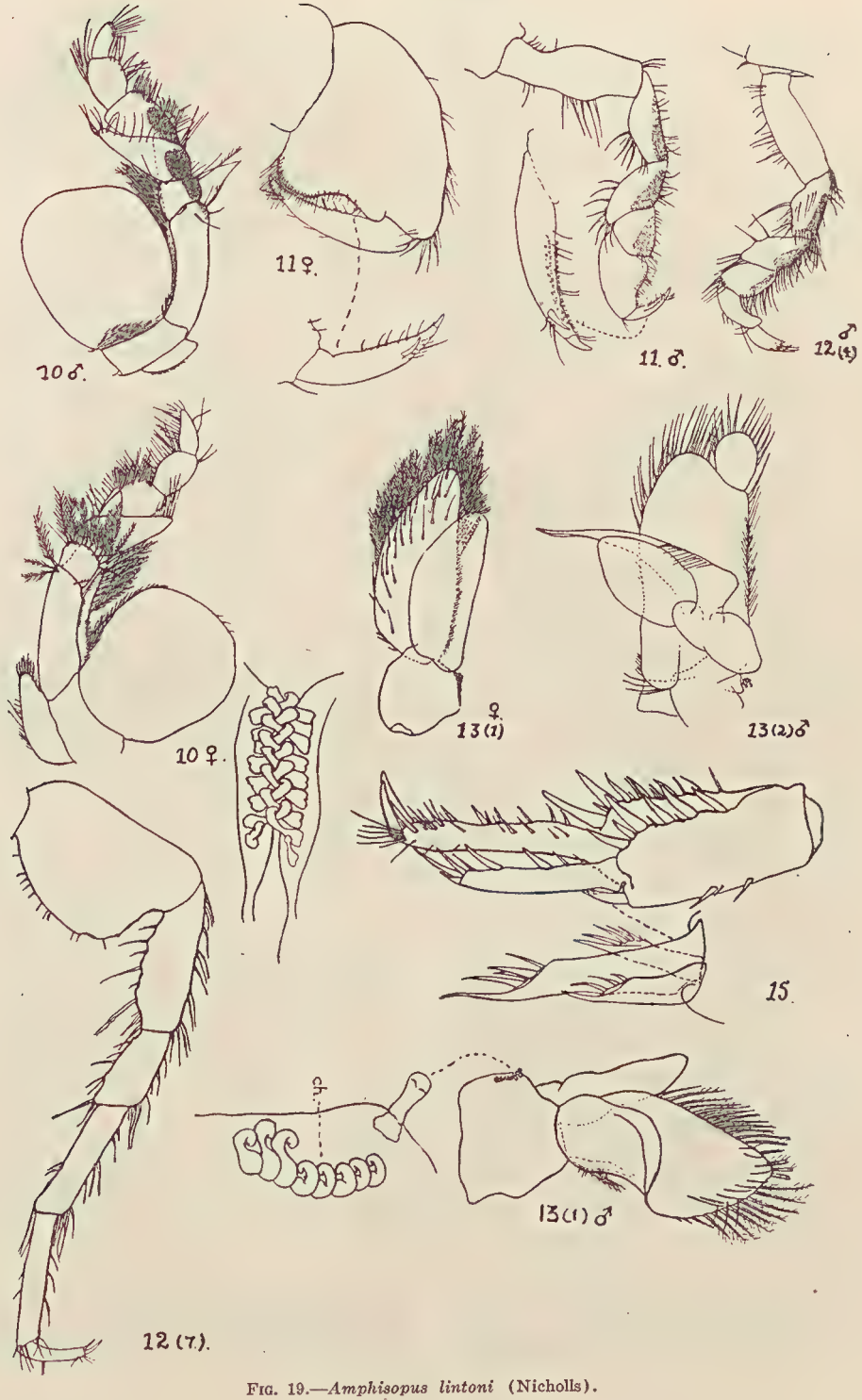


FIG. 19.—*Amphisopus lintoni* (Nicholls).

setae rather widely spaced; the second pleuron has a similar short, gently convex, inferior margin with one or two spiniform setae anteriorly, while on the postero-inferior angle are several stronger setae, the intervening space being fringed with fine hair-like setae more closely set than those which continue onto the posterior margin; the third and fourth differ little except that they are broader and there is a posterior rounded angle; the fifth has a broadly-rounded inferior margin which, except for a couple of stiff setae anteriorly, bears only close-set hair-like setae.

In life, the *pleopods* are clearly visible, below the pleura, the greater relative length being partly due to the largely-developed sympodite. In the male, the exopodite of the first pleopod (fig. 19, *13(1)*) has a strongly curved transverse fold corresponding to the great curve of the penial stylet; plumose setae are practically confined to the distal half and are numerous and close-set, a fringe of short, fine setae, or variably, one or two plumose setae edging the excavated proximo-lateral border; some long simple setae are scattered over its anterior face distally. The endopodite is short and may be emarginate, almost bi-lobed; the mesial border of the sympodite is produced into a short flange on the straight edge of which are the numerous coupling hooks (fig. 19, *c.h.*). The inner edge of this flange seems to be bent upon itself, almost at right angles and the hooks, for the most part, arise just within the margin and are thus likely to be overlooked unless careful search is made, whereas in *A. annectens* and *P. palustris* some or all of the hooks project well beyond the free edge. The second pleopods (fig. 19, *13(2)*) are scarcely wider than the first, the exopodite produced into a small and narrow latero-proximal lobe almost devoid of setae, as well as being divided into proximal and distal plates bearing plumose setae. On the lateral border these plumose setae extend some distance proximally, but, on the mesial border, they are almost wholly replaced by long, simple setae, which extend nearly to the proximal end of the plate; the lamellar lobe of the endopodite is relatively smaller than in the corresponding appendage in *P. palustris*, but the basal segment is stout and well developed and gives rise to a very strong penial stylet which has the shape characteristic of the Amphisopinae, strongly curved and tapering to a flattened pointed apex. Along its inrolled mesial edge is a row of short, stiff setae, comparable to, but fewer than, those found in *Mesamphisopus* and *Eophreatoicus*. On the sympodite, the coupling lobe is smaller than in *P. palustris* and is rounded and knob-like with but three coupling hooks and with one stiff seta; the lateral aspect of this sympodite is produced into a thin flattened plate, better developed than in *palustris*, and is armed with a single stout spiniform seta distally. On the remaining pleopods, the sympodite is narrower, lacking this lateral extension, but in its place springs the epipodite, sub-triangular with rounded angles, attached by a narrow base and fringed with long, simple setae which are much more closely set on the mesial border. In the third pleopod, both exopodite and endopodite are broader, the former produced proximally as in the preceding appendage into a well-developed proximo-lateral lobe lying immediately posterior to the epipodite; the endopodite extends ventrally nearly to the insertion of the distal plate of the exopodite and springs from a short proximal muscular segment; the coupling lobe is smaller and angular and bears but a couple of setae. The endopodite narrows slightly in the fourth and considerably in the fifth, the epipodites decrease in size, the coupling lobe becoming longer and narrower; in the fourth it bears several setae and is reduced in size.

In the female, the first pleopod (fig. 19, *13(1)* ♀) is unmodified, it has exopodite and endopodite much more nearly equal, both lamellae being narrower and sub-acute, the exopodite densely fringed distally along both borders with plumose

setae and mesially, in the proximal half, with short, simple setae. Laterally, the border is not excavate and there are a few widely-spaced simple setae. On the anterior face of the lamella are scattered, stiff, simple setae, principally in its lateral half, more numerous than in the male. The endopodite is larger, relatively, and shows no modification into distal and proximal portions. The sympodite bears fewer coupling hooks. The second pleopod differs from those following chiefly in that it is narrower and lacks an epipodite.

The ventral pleural margin of the sixth pleon segment (fig. 18, *3s.*) is very short, the almost vertical anterior margin meeting it in a steep curve upon which is one short spiniform seta followed by four to six spines increasing in size to the most distal which underlies the insertion of the uropod. Immediately adjacent to this spine dorsally is a close brush of fine setae, elsewhere lacking from this margin. The postero-inferior part of the tailpiece ventral to the dorso-lateral notch (the telsonic pleuron) is broadly convex, but its margin is raised into three prominences about equally spaced, each crowned by a very stout spine; in the intervening gaps are setae, which may be spiniform, the border distal to the last of these spines and dorsal to the actual insertion of the uropod bears two or more spiniform setae and other finer setae. Above the dorsal angle of the insertion of the uropod, a short rank of three to five very stout spines dorsally directed marks the suture of sixth pleon segment and telson.

The peduncle of the *uropod* is stout, in transverse section sub-triangular, both inner and outer faces curved, meeting in a rounded edge below, which appears smooth, but on closer examination reveals the presence of several spinules, usually three, each of which may be associated with one or more fine setae. These are borne slightly laterally, and may be folded down, in which condition they are easily overlooked. The ventral distal angle beneath the origin of the outer ramus is occupied by a stout spine (fig. 19, *15*) with its end obliquely truncated, the oblique dorsal face toothed. Mesially to this, and in lateral view hidden by it, is a shorter but similar spine, and externally, a third. Such toothed spines in this position occur also in *Synamphisopus*, but are otherwise confined to the Phreatoicinae, no member of that sub-family being without them, except the two species of the genus *Phreatoicus* s.s. The dorsal face of the peduncle is concave forming a deep groove, narrow proximally, but widening distally. The curved dorso-lateral border, fringed with about eight spines, slopes downwardly to a point but little above the ventro-distal angle. The strongly-curved mesial edge, on the contrary, rises dorsally to an angle well above the level of the insertion of the inner ramus. It bears about five stout spiniform setae, and, at its postero-distal angle, two spines separated by a stout spiniform seta; the distal spine is stout and long, being nearly half the length of the outer ramus. Both rami appear rounded but are actually slightly concave dorsally, the inner, which is rather the longer, is as long as the peduncle, has its margins armed by four pairs of spines interspersed with finer setae, its obliquely truncated end having two long and one shorter spines and a sub-terminal tuft of very fine setae. The outer ramus is rather more slender and likewise has four spines, while terminally are one shorter and one very long spine, the latter extending just to the end of the inner ramus; there are, in addition, several terminal spinules, apparently variable in number.

Colour. Variable, dark grey to chestnut brown, mottled or marbled and banded.

Size. Largest female taken 20 mm.; largest male 13·5 mm.

Habitat. On submerged stakes or snags or under vegetation growing in water—many localities around Albany, W.A., and east as far as 'Two-people Bay'.

In this district one specimen was found in the pitcher of *Cephalotus*; it is apparently strictly coastal—some localities at Albany being within a few yards of the sea—as is the case with some New Zealand surface-living forms.

Amphisopus annectens, sp. n.

(Figs 20, 21)

Like *A. lintoni*, from which it differs in most of the following characters: It is a much smaller species, the body more slender, with abundant scattered setae; eyes of moderate size (with about fifty ocelli), separated by less than twice the long diameter of the eye; cheek notably scaly. All of the segments in the peraeon show setules sub-marginally along the hinder border; the pleon is shorter, having, with the tailpiece, a length almost two-thirds of that of cephalon and peraeon combined; all pleon segments having posterior margin slightly excavate, that of the fifth being deeply notched, the ventral and posterior edges of the pleura being armed with spaced setae.

The telsonic apex is very slightly emarginate, the emargination angular, while from the mesial side of the notch on either side of it, the lateral ridge is armed with setae; two relatively immense spines rise from the posterior border just below the level of the dorso-lateral notch, followed by a number of spiniform setae of various sizes on the postero-inferior margin; the suture between sixth pleon segment and the telson bears two or three strong spines and, more posteriorly, a spiniform seta, the inferior margin of the sixth pleon segment being armed posteriorly with a stout spine preceded by a smaller spine and two spinules, while the whole of the vertical anterior margin is densely fringed with fine setae.

The *antennule* is little longer than the peduncle of the antenna, its flagellum having thirteen joints which are not noticeably widened distally; the antenna is nearly two-thirds of the length of the body, the flagellum with relatively few (about twenty) joints.

The rank of long setae across the outer surface of the upper lip (fig. 20, *5a*) runs in a very broken line, being much less complete than in *lintoni*.

On the *right mandible* (fig. 20, *6r*) the lacinia mobilis is very slight and transparent, the spine row followed by a series of plumose setae or slender setospines; the palp with fewer setae; the apex of the inner endite of the *maxillula* is obliquely truncated and has eight setospines which tend to spread onto the mesial border. At the proximal end of the inner endite, the *maxilla* has a short anterior row of simple setae, not observed in *lintoni*; the endite is scarcely divided into basal and distal portions and the row of filtratory setae passes nearly to the apex, while the posterior sub-marginal row of pectinate setae (about fourteen) passes onto the posterior face, short of the apex; lateral to these distally is a short line of simple setae; all the apical spines on the distal endites are stout, but on the inner of the distal endites are one or two particularly strong denticulate spines. The *maxilliped* (fig. 20, *10r*) shows a small coxal lobe which is slightly setose in the immature female and markedly setose in the ovigerous condition; it may be present, also, though much smaller and unarmed, in the male; the basal endite carries brush setae along practically the whole of the dorsal edge; a fringe of setae springs from the outer border of the dactyl. Between, and anterior to, the maxillipeds a median process is strongly developed. The pilosity found in the male of *lintoni* on several joints of this appendage and on the gnathopod and fourth peraeopod is not apparently developed in this species. The palm of the gnathopod (fig. 21, *11*) is concavo-convex, the convex posterior part

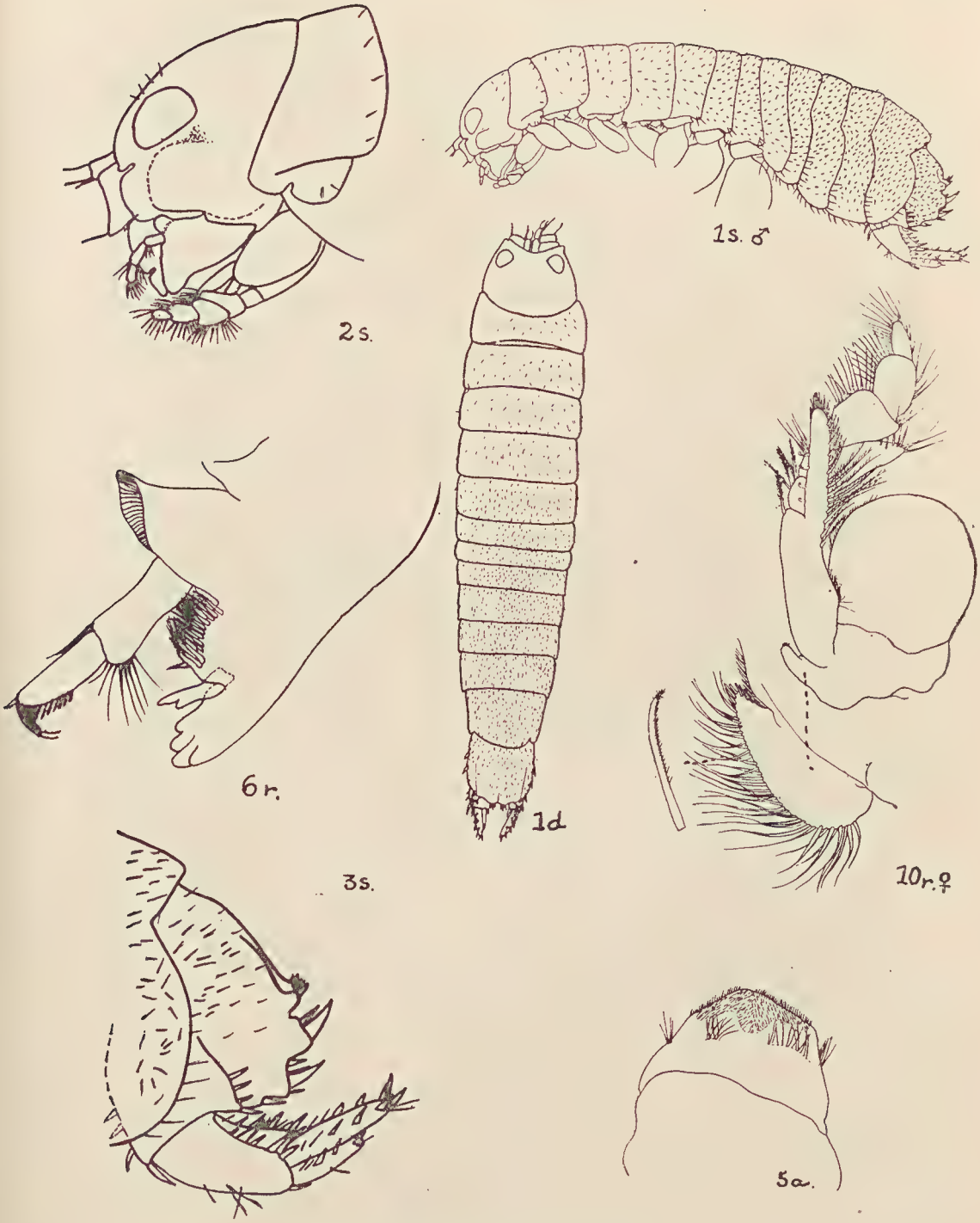


FIG. 20.—*Amphisopus annectens*, sp. n.

armed with long setae in the female; in the latter the dactyl is strong, its palmar edge bearing a series of stout teeth. The peraeopods are slender, the fourth (fig. 21, *12(4)♂*) in the male modified perhaps even more obviously than in *A. lintoni*; it is apparently not used in walking, and its basis is not expanded. Instead of the pilose area on the posterior surface, the propod of the fourth peraeopod in the male in this species has developed a curious granulation of the *anterior aspect* of this joint. The coxae of the fifth, sixth, and seventh peraeopods are well defined, the bases (fig. 21, *12(7)*) expanded, the anterior border of the joint being markedly setose, the posterior having a few scattered setae; in the seventh the hinder margin of the basis is irregularly crenate and the 'inferior notch' well developed; upon the bases of all three of these appendages there are scattered setae on the outer surface.

In the first *pleopod* (fig. 21, *13(1)*) there is found the development of simple setae over much of the anterior face of the exopodite in the female, and more distally in the male; in the latter the fringing setae on this lobe are bushy and the lateral excavation of the exopodite and the curved fold across its face are also very marked; coupling hooks are particularly well developed on this, but are fewer on the second pleopod; in the second and third these are borne on an outstanding coupling lobe, and in the third and succeeding pleopods the hooks decrease in number, but may be followed by short setae; the proximo-lateral lobe of the second pleopod is fringed with short setules, much of the more distal border being unarmed, while plumose setae extend for one-fifth of the mesial border of the exopodite. A feature of the second pleopod (fig. 21, *13(2)*) in the male is the ramarkable development of the peduncle of the endopodite, while the penial stylet is very strong. In the third pleopod, the long setae on the epipodite are finely pectinate, those on the exopodite plumose, but these do not reach the proximal end of the lamella on either border. The first pleopod is the shortest; second, third, and fourth are longer, the fifth somewhat shorter than the fourth (in these proportions resembling *australis* rather than *lintoni*).

The *uropod* (fig. 21, *15*) has a rather stouter peduncle, relatively shorter than that of *lintoni*, its inferior border with two or three tufts of setae, its disto-mesial angle less produced into the usual shallow, blunt process armed with spines, of which only one is long; the inner ramus is as long as the peduncle, and is furnished with spines as in *A. lintoni*; the outer ramus is relatively shorter with one terminal spine, unusually stout. Beneath the insertion of the outer ramus are one stout and a second and third more slender, toothed spines, much as in *lintoni*. Higher on the inner distal end of the peduncle, are one or more slender toothed spines—evidently a vestige of the series of such setae in this position in *Hyperoedesipus*.

Colour. Light to dark grey, the colour varying with the abundance of dendritic black chromatophores on a pale cream-coloured background.

Size. The largest specimen obtained measured about 10 mm., males and females being of equal size; females of just over 5 mm. are found with incipient brood-pouch; the number of embryos found in the pouch apparently not exceeding fifteen.

Habitat. A single specimen was taken (December, 1927) in a foliose Jungermannia-like liverwort around the mouth of a spring which gushed out in boggy land, just on the edge of well-grown Karri forest about seven miles south of Pemberton, West Australia. In July, 1928, a number of others (of which a few were kept alive in the laboratory until the following December) were secured in the surface mud along the banks of a drain issuing from the bog, on this occasion associated with a large Neoniphargid.

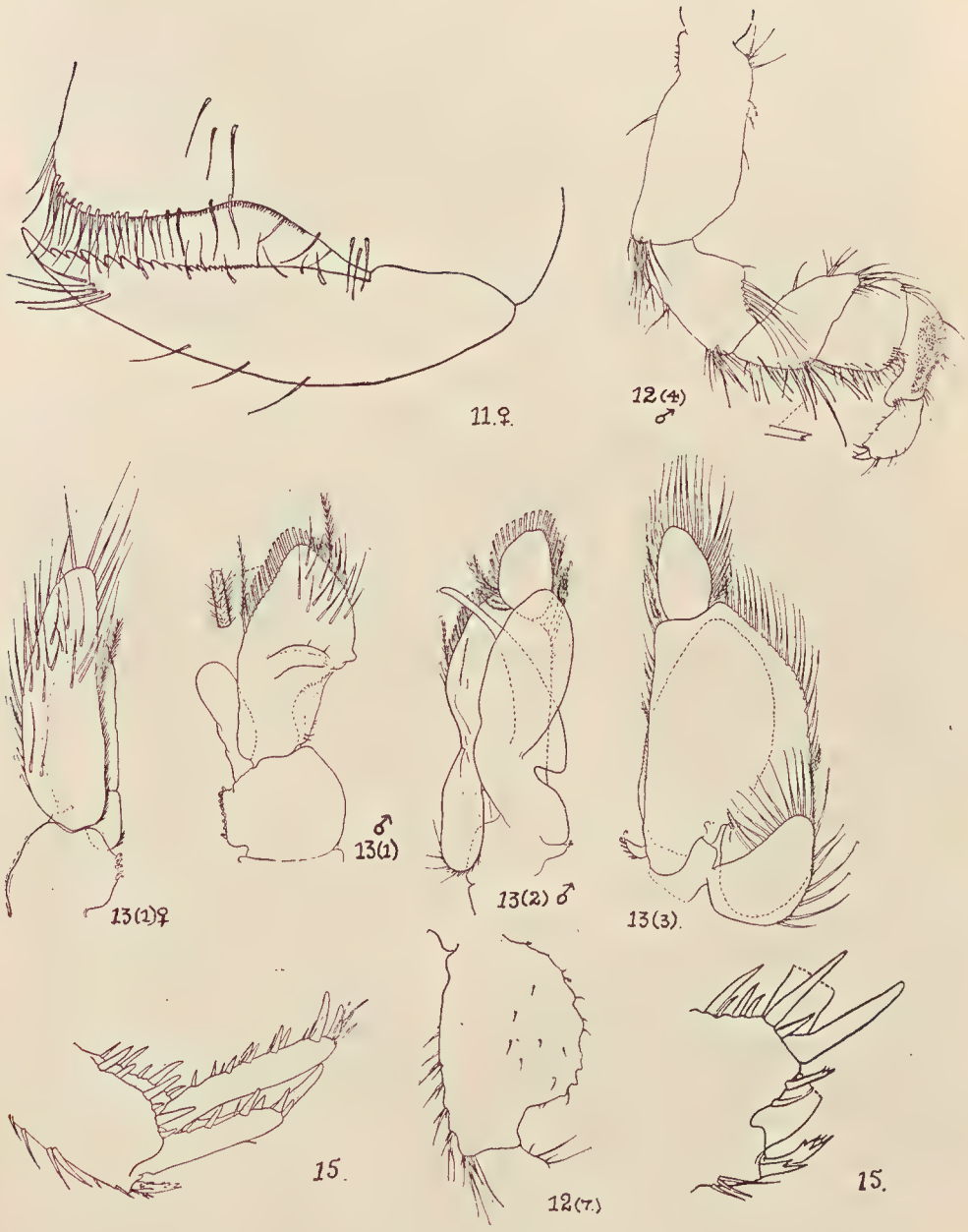


FIG. 21.—*Amphisopus annectens*, sp. n.

Co-types are lodged in the collection of the Museum, Perth, W.A.

In the period 1930-1940, two other Amphisopids have been taken in Karri forest country—both of these having been provisionally referred to this species. Material is too scarce for sufficiently detailed study, but it seems probable that forms from these two localities will prove to be distinct. One was collected from small patches of sphagnum in dense forest country about forty miles south-west of Manjimup, that is, about twenty-five miles in a direct south-easterly line from the type locality for *annectens*. The creek along the banks and in the bed of which the sphagnum occurs may possibly flow into a tributary of the Deep River; it is separated from the Warren region by the Shannon River system.

Nearly forty miles farther to the south-east, at Walpole, near the junction of the Frankland, Walpole, and Deep Rivers, is another small swamp from which the third form has been taken sparingly. In the seventy or more miles between Walpole and Albany no trace of Phreatoicid has so far been found.

Sub-family III. PHREATOMERINAE

Body depressed. Head small, without cervical groove, almost embraced by first peraeon segment which is short, but greatly produced antero-ventrally and fused with head, except for a free margin; eyes large and prominent. Peraeon greatly widened, greatest width (in the female) nearly equal to half the length of body; telson with narrow median incisure. Antennule relatively long, filiform; antenna short. Peraeopods, with coxae greatly reduced, one to three prehensile, two and three feebly sub-chelate; basis, ischium and merus expanded; fourth peraeopod not sexually modified; bases of hinder peraeopods greatly expanded, dactyl long. Pleopods with lamellae oval, relatively wide, sub-equal, with anterior face of exopodite armed with a number of short ranks of stiff pectinate spines; with coupling hooks on sympodites of first to fourth pleopods; both first and second pleopods modified in male; penial stylet very stout, strongly curved, unarmed. Uropods, with rami truncated and continued by freely movable terminal spines. With very large number of embryos in brood-pouch.

Phreatomerus, the only genus included here, is probably the most specialized and least typical of surface-living Phreatoicids. The condition of the head is unusual; the depressed peraeon, which may reach a width equal to one half, nearly, of the total length of the body and is followed by a pleon appearing strongly compressed, constitutes an ensemble which has no parallel in Isopoda. The telson is unique in the sub-order, if not in Isopoda, in being cleft.

It survives in the arid region, an area which, in Cretaceous times, was submerged by the sea, and to-day it is found in the strongly-flowing, hot, and slightly salt water—the overflow from a bore of comparatively recent date. Clearly, there must be hide-outs in this arid country, where it has managed to persist and from which it has reached the bore overflow, so that a search in this region will probably reveal other species. Its relationships seem about equally with *Paramphisopus* and *Phreatoicopsis*.

Phreatomerus Sheppard

Head very short, embraced by first peraeon segment, sub-ocular incisure on head clearly indicated; cervical groove wanting; peraeon broad, depressed, the pleura being greatly developed and out-turned; pleon moderately compressed; telson incised, not produced into terminal projection. Antennule relatively long,

much longer than peduncle of antenna. Coxae of first to fourth peraeopods hidden beneath the downwardly produced pleura of their related segments to which they are immovably united, except in the female in which the second, third, and fourth coxae are apparently free; while those of fifth to seventh peraeopods are completely fused with related segment in both sexes; gnathopod of male and female alike, except for difference in size. Second, third, and fourth peraeopods with terminal three joints involved in grasping mechanism; fourth peraeopod of male not sexually differentiated; bases of three hindmost peraeopods exceptionally expanded and dactyls very elongated; posterior margins of pleon segments with sparse setal fringe; pleopods with lamellae sub-equal, sympodite on all pleopods bearing mesial coupling lobe with entangling setae and coupling hooks; both first and second pleopods modified in the male; suture between last pleon segment and telson strongly developed; peduncle of uropod with mesial distal process strong, spine beneath insertion of rami of uropod stout and simple, rami slender with movable terminal spines.

Genotype. *Phreatomerus latipes* (Chilton).

Phreatomerus latipes (Chilton)

(Figs 22, 23)

Chilton, 1922, p. 23, and 1924, p. 9 *(Phreatoicus latipes).*
Nicholls, 1924, p. 92 *(Phreatoicus latipes),* and 1926, p. 182 *(Amphisopus latipes).*
Glauert, 1924, p. 161 *(Phreatoicus latipes).*
Sheppard, 1927, p. 113 *(Phreatomerus latipes).*
Hale, 1929, p. 326 *(Phreatoicus latipes).*

As is shown in Chilton's figure (1922, p. 27, fig. 1), the animal can roll up almost as completely as a Sphaeromid or an Armadillid. The body is stout (with slight wrinkles and irregularities on most segments) its surface appearing nearly smooth. Actually, it is scaly and, in the posterior region particularly, bears a number of fine short setae. It is so strongly depressed and so broadened that its length is little more than twice its greatest width. The head is flattened and, unique in this sub-order, appears sub-pentagonal as seen from above; is rather wider in the male than the female; it is notably concave anteriorly with a distinct median vertical ridge (rostrum?) and, again peculiar among Phreatoicids, extensively embraced laterally by the first peraeon segment. Its dorsal surface is strongly sculptured, the eyes black, large, and very prominent with numerous ocelli (80 or more). The cervical groove which is so well marked in the Phreatoicidae where it runs vertically upwards from the ventro-lateral border of the head, near its hinder edge, seems here to be completely wanting, unless a short groove exposed upon the side of the head, *ventral* to the forwardly produced and outwardly projecting pleural flap of the first peraeon segment, may represent the last vestiges of this suture. If the projecting part of this first peraeon segment be cut away, the groove can be traced for some little distance dorsally. If this groove in *Phreatomerus* really represents this suture, it is unusually forwardly displaced, but in any case the anterior border of the first peraeon (gnathopod) segment has here moved forwardly more than in any other Phreatocid into the plane of the immediately anterior segment, almost wholly concealing the post-mandibular part of the head.

The length of the peraeon is practically one-half of the total length of the body; it is broad, strongly depressed and only moderately convex, all the segments from the second to the seventh having a slight transverse groove which

FIG. 22.—*Phreatomerus latipes* (Chilton).

divides them into very unequal parts, the smaller anterior band being almost wholly overlapped by the preceding segment when the animal is extended; the pleural portion of the first four peraeon segments is produced outwardly and slightly downwardly so that, in dorsal view, it conceals not only the coxa but, also, about the proximal third of the basis. The first peraeon (second thoracic) segment is very short in the middle line but greatly expanded laterally and is immovably joined with the head, the suture being well marked and the lateral pleural border turned outwardly, producing, in ventral view, the effect of an extensive thickening. Anteriorly, it is produced nearly halfway along the ventro-lateral region of the head to which it is firmly attached and immovable; although having an appearance of freedom, actually only the anterior projection of the epimeron is free; the second, third, and fourth segments are also forwardly produced but less strongly, each underlying the segment preceding. Owing to their great lateral expansion, these three segments appear in side view (fig. 22, *1s*) as much deeper than the segments which follow them. The pleon is relatively short, narrow, and scarcely more than half of the total length of the cephalon and peraeon. It appears laterally compressed, and the pleura are greatly produced (in the fourth and fifth segments almost twice the depth of related segment). The anterior and posterior borders, which are in some segments sparsely fringed with long setae, meet in a rounded angle, so that an inferior margin is absent, but a ridge runs dorsally from the ventral end more or less parallel to the anterior border, marking off a narrow anterior area. In the hindermost pleon segment a wide (re-entrant) angle marks the junction of the pleuron with its related segment. The sixth is united with the telson, but the suture, which in other members of the sub-order has been interpreted as the vestige of its posterior boundary, is here a well-defined ridge which traverses the entire tailpiece, reaching almost to its anterior border (fig. 22, *3s*). The telson is strongly arched above and the convex posterior border is unique in this sub-order in being incised. It is fringed with spines and setae.

The *antennule* (fig. 23, *4*) is relatively long, varying from three-fifths to two-thirds of the length of the antenna (in the male barely half), its peduncle with first joint broad and long, very setose, second barely two-thirds of length of the first (or of third), third slender, not quite as long as first, followed by a flagellum of nine joints (female) or ten (male) which is very slightly longer than peduncle; there is an olfactory cylinder on the end of the sixth to ninth segments accompanied by sensory setae of slightly different type and with a bunch of these latter terminally. The *antenna* is stout and unusually short, approximately one-fourth of the length of the animal, with first joint of peduncle very short, second slightly longer, third and fourth sub-equal, each about as long as combined length of first and second, the fifth half as long again as the fourth and less stout than the four more proximal joints; the flagellum, as long as the peduncle, may have as many as twenty-two joints, all setose, the more proximal joints being stout (as broad as long) the terminal more slender.

The mouth parts are stout and, in general, resemble more closely those of *Phreatoicopsis* than of *P. australis*, to which Sheppard and Chilton compare them. The upper lip, which is strongly asymmetrical, has the lateral tuft of setae, so characteristic of many Amphisopine forms, well-developed.(1)

The *left mandible* (fig. 22, *6l*) shows the cutting edge stout, dark, and heavily chitinized, with four strong teeth; lacinia mobilis well developed with but three teeth. The spine row is prominent and is followed by about eight ciliated setae;

(1) Lacking in *E. kershawi* and *M. capensis*.

on the opposite appendage the lacinia is less stout and its three teeth appear bifid. The molar is long, its surface very oblique. The palp is short, the third joint armed with a double row of setae, one row with setae pectinate along one edge, the other simple setae.

The *lower lip* is stout, the outer lobes not quite so incurved as in *Phreatoicopsis*, with a dense terminal tuft of long setae, the inner lobe fringed with a fur of very short setae; the outer border has the characteristic detached tuft, and near the base, these setae becoming very short and obliquely set.

The *maxillula* (fig. 22, *8*) has seven or eight (rarely six) setospines at the apex of the inner endite, the outer endite about twelve or thirteen spine-teeth, the four most laterally placed long and curved, the rest shorter and so coarsely pectinate as to suggest denticulation; both the outer and inner borders of the distal endite and inner edge of inner endite are fringed with long fine setae, but the outer border of this latter endite is almost devoid of setae.

The *maxilla* (figs 22, 23, *9*) agrees very closely with the description given for *P. palustris*; the setae on the apex of the proximal endite are very crowded, the inner distal endite is rather slender but the outermost is quite short and wide, with fifteen or more setae (Sheppard says nine or ten, a statement based, perhaps, on immature or juvenile material).

The *maxilliped* (fig. 22, *10*) is more heavily setose than in any other Phreatoicid, with the exception of *Synamphisopus*—a condition which might be supposed to be related to its mode of life (free swimming in open waters) were it not for the fact that a relatively high degree of setosity is found also in *capensis, annectens, tasmaniae, Notamphisopus*, spp., and *australis*, all of which, except *tasmaniae*, have a comparatively sheltered habit of life beneath stones or encrusting vegetation. In still more sheltered habitat, however, as, for example, in underground waters, this setosity tends markedly to decrease. It seems probable, therefore, that such setosity was a primitive characteristic. In many specimens, these setae were thickly encrusted (as, is frequently the case, in *Phreatoicopsis terricola*) with infusoria. The epipodite, shallowly convex, is in outline almost circular, its mesial distal border edged with fine setae (omitted from Sheppard's figure—1927, fig. 1 (4)); the basis is curved, rather narrow, considerably more than twice as long as broad, its mesial border sparsely setose with one terminal tuft of long setae; the merus produced laterally and distally almost as far as the distal end of the carpus, with its internal border markedly convex; it is free from setae only for a short part of its latero-proximal border; the carpus has its mesial border very convex, its outer distal angle barely projecting beyond the merus, all of its free border fringed with long setae; both propod and dactyl are a long oval in shape—the dactyl much the narrower, with a practically continuous fringe of setae. From the basis, the endite projects as far as the inner distal border of the merus, its rounded apex set with long brush setae which continue, as more sparsely feathered setae, along its dorsal edge nearly to the proximal end of the plate. The small lobe upon the coxa of the maxilliped in the female is, prior to the development of the brood-pouch, a stiffly projecting setose flap, median and vertical in position. At its fullest development, it is enlarged and becomes bent obliquely outwards, in a medio-lateral plane within the brood-pouch, its concave surface directed mesially, its border fringed with long recurved setae, many of which are plumose. Together, these setae form a strainer-like fringe which fills in the tiny gap between the mesial borders of the anterior lobe of the first pair of oostegites. From their disposition, it seems improbable that these can function (as Miss Sheppard suggests) in producing the aerating current through the brood-pouch, the flaps being more or less secured in place by the pressure of the

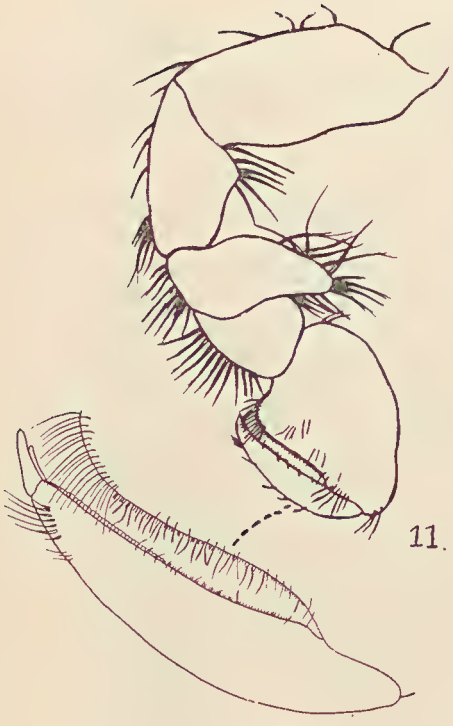
first pair of oostegites. It would seem that this current might be indrawn anteriorly by the action of the pleopods which swing in a well-defined channel bounded by the pleural walls, and which are natatory as well as branchial, but in living forms examined no appreciable ingoing current was discovered. It appears probable that these setose lobes upon the maxillipeds are strainers only, although they may perhaps serve to shift the eggs.

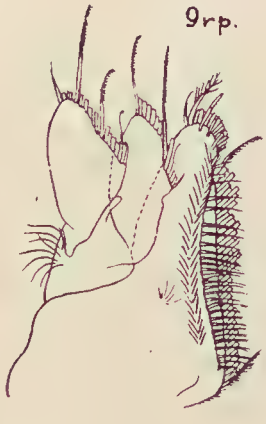
Peraeopods. The notably depressed condition of the peraeon is due in part to the actual broadening of the body in this region (cf. Chilton, 1922, fig. 2)—this being even more evident in the female. Associated with this, is a very definite outward development of the pleura of the first four peraeon segments, so that these latter present a large ventro-mesial surface (instead of a ventral edge which is the practically invariable condition in other Phreatoicids). In the case of the first peraeon (second thoracic) segment, it presents an actual ventral surface, triangular in shape and concave as seen from below. Related to this modification, the coxae of the peraeopods of these segments have coalesced with the pleura and are completely hidden in side view—but seen from below are bent inwards towards the mesial border of these pleural surfaces. The bases (relatively shortened and broadened) are, also, overhung in some cases for more than a third of their length.

Gnathopod stout, strongly sub-chelate, propod sub-triangular, smaller in the female, palm straight and (alone amongst Phreatoicids) entirely free from spines or denticles; in place of these the palm is setose and bears between the setae, a continuous fringe of setules; the palmar edge of the dactyl seems incised, forming an edging of short blunt spinules; these, which line the distal half of the dactyl in the female, are more restricted in the male. There is a group of two or three spinules antero-proximal to the base of the dactyl (fig. 23, *11*), and the dactyl bears a stout secondary unguis. The second, third, and fourth peraeopods are similar (except for the hand) but more slender than the gnathopod, with posterior border of carpus and propods densely set with stout setae, the propod narrower and the dactyl exceptionally elongated, secondary unguis present; all three appendages obviously capable of a strong grasp, the tip of the dactyl, when clenched, burying itself in the setal fringe of the merus; the fourth in the male not differing from that of the female, but with propod longer and more slender than in second and third. In this unmodified condition of the fourth peraeopod in the male, we have, perhaps, a primitive condition shared with *Phreatoicopsis, Eophreatoicus,* and *Paramphisopus,* departed from in *Amphisopus* and *Mesamphisopus* and, in a different fashion, by *P. typicus* slightly and in other Phreatoicids very markedly. The fifth, sixth, and seventh peraeopods are alike, but increase progressively in length of limb and degree of expansion of basis in which latter feature they reach a development attained by no other extant Phreatoicid and approaching rather nearly the condition seen in the extinct *wianamattensis.* The expanded part of the basis consists chiefly of a thin plate defined from the rounded, muscle-containing portion by a strong ridge running parallel to the anterior margin; ischium and merus, also, are produced posteriorly, but in these it is not a plate-like expansion but an actual widening of the joint for the accommodation of muscles. The ischium in the peraeopoda generally is rather shorter than usual. In the three limbs of the hinder series, the dactyl, too, is extremely well-developed (again as in *wianamattensis*).

The brood-pouch in this species is very large and may contain as many as 109 embryos—the largest number recorded for any Phreatoicid.

The male appendage is unusually long, slender, tapering, and recurved, with its mesial border deeply grooved.





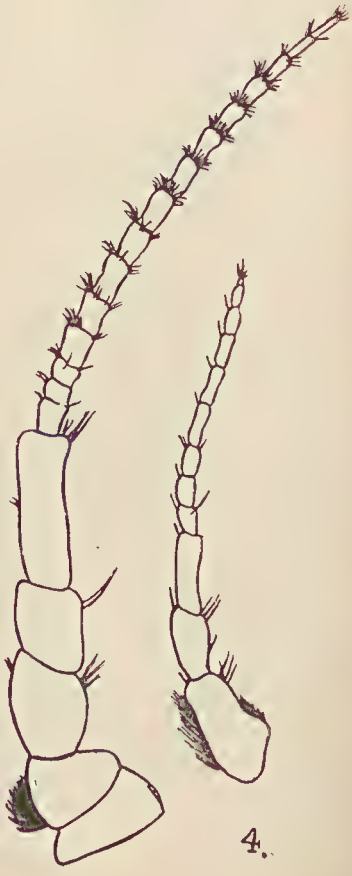


FIG. 23.—*Phreatomerus latipes* (Chilton).

The *pleopods* show a far greater resemblance to those of *Amphisopus* than to those of *P. australis*, to which Chilton compared them (1922, p. 30). Sheppard's statement that, in this species, there is a replacement of plumose setae on the exopodite by simple setae is quite incorrect. There are, however, numerous other and more striking differences.

In the first pleopod (fig. 23, *13(1)*) the sympodite is shorter relatively than in *P. palustris*, having a wide-based and convex mesial plate well developed, carrying long, stiff setae and three or four coupling hooks on its free edge; exopodite and endopodite are sub-equal, the former, in the female, fringed from the sub-apical part of its mesial border to the proximal end of its lateral border with sparsely feathered setae, about fifty of these being counted; fewer (thirty-nine) were found in a male of comparable size, these setae being absent (in this sex) proximally, since, in the male, the proximal fourth of this border is thickened and spinulose, a condition rather like that of *Amphisopus* species and one that is found also in some other Isopods (e.g., *Asellus*). Generally, on the hinder face of the exopodite, there is a scattered sprinkling of sub-marginal setules.

The second pleopod (fig. 23, *13(2)*) is larger; in the male, the endopodite is narrowed and reaches to the middle of the distal lobe of the exopodite, the penial stylet being stout basally, tapering sharply and curving laterally to its apex, which is devoid of setae, its mesial surface is deeply grooved, its inrolled edges setose. The exopodite is well fringed; distally with fully-plumed setae only, the inner border bears a dense fringe of stiff pectinate setae mixed with simple setae; sub-marginally upon the anterior face along the mesial border are short ranks of four or five stout pectinate spinules. The lateral proximal lobe of the exopodite is well developed; from the sympodite the mesial coupling lobe projects, rounded and distally directed, bearing numerous long setae and a few (two or three) short coupling hooks which spring from the anterior face and are, therefore, not seen in profile; on its outer border, a flat flange is evident and is divided into proximal and distal areas.

The third, fourth, and fifth pleopods are generally alike and differ from the second in the greater width of the lamellae, and in bearing an epipodite, this latter arising from a narrow base and being, in shape, a long oval; it is fringed with long, stiff setae, of which some are pectinate. On the sympodite, entangling setae are more numerous and are pectinate, while coupling hooks are fewer, generally two on the third and fourth and one only on the fifth, this last being sometimes wanting. In general, the setae are more closely set and more numerous upon the distal lobe of the exopodite than in other species, there being as many as fifty,[1] but of these some (twenty or more) upon the mesial border of the distal lobe are pectinate with short pectinations on two edges of the seta.

In the female, the pleopods appear less setose and in the case of the second the endopodite is relatively considerably longer.

Tailpiece and *uropods*. The paired lobes into which the terminal telsonic region is produced are separated by a narrow median incisure, the lobes being strongly convex, their apices set with setae. Beneath, the telsonic pleura are well developed and broadly convex, their edges set with a practically continuous fringe of stout spiniform setae and spinules, standing out from these being the three paired spines so conspicuous in *Amphisopus*, *Paramphisopus*, and *Synamphisopus*. The anterior margin of the tailpiece descends steeply bearing one or two

[1] As against twenty to thirty usually found in other species (cf. *Synamphisopus* and *Phreatoicopsis*).

longish setae, and then passes into the inferior margin which is armed by one or two spiniform setae and two more posteriorly placed spines. Inferior and posterior margins are separated by the broad insertion of the uropod, somewhat dorsal to which appears a well-defined ridge or suture set posteriorly with a few stout and freely movable spines; it is continued forwardly for some distance towards the anterior border of the tailpiece, being set with a fringe of fine spines and spinules.

The *uropod* (fig. 22, *3s*), with stout peduncle, broadly concave above, its inner edge set high with a nearly continuous fringe of spines and spiniform setae, is raised distally and bears there two or three much larger spines; the outer edge at a lower level has rather fewer and more widely-spaced spines. The ventral border bears four long and slender spiniform setae not represented by Chilton (l.c., fig. 4), being overlooked probably because they may be folded against the ventral border; inner ramus slender, as long as peduncle, with about five (paired) spines and one longer, flanked by two shorter, on the truncated extremity. The outer ramus is but two-thirds the length of the inner, has three lateral (unpaired) and two longer terminal spines; all of these on both rami being movable. Beneath its insertion springs the usual stout spine which is here without teeth and is guarded on either side by a long and slender spiniform seta.

Colour. In most preserved material, these Isopoda appear a uniform slate colour; in some, however, the head shows patches free from pigment—very strongly reminiscent of the yellow areas on the head of *Phreatoicopsis* and *Phreatoicoides*. In some examples this patch is faintly brown and the middle line of body shows a band of chestnut brown. Two specimens sent by Mr. Sheard arrived still living—one showed the patchy coloration described above, the other (perhaps recently moulted) was uniformly pale brown in colour. Pigmented patches are well developed on exposed surface of maxilliped (less on the epipodite), maxillae, and mandible. The labium, too, though practically concealed, is heavily pigmented, as are the under surfaces of the pleura in the peraeon and parts of the pleopods. Occasionally, small specimens appear paley grey with widely separated dentritic black chromatophores.

These creatures are so unlike other Phreatoicids that even Chilton, in a note probably written when he first received them from Professor Wood Jones, referred to them as 'some Amphipods' (1924, p. 9). Actually (apart from the great expansion of the bases and other joints of the peraeopods) they, more nearly than any other members of this sub-order, bear a resemblance to terrestrial Isopods.

Sub-family IV. PHREATOICOPSINAE

Body sub-cylindrical. Head moderately long, with or without cervical groove; eyes large or small with many ocelli. Antennule long, filiform; antenna short. Peraeon segments not differing greatly in length; telson little or not at all produced; pleopods with lamellae lanceolate, sub-equal, without coupling hooks on sympodite; epipodites persist on three or four pairs; penial stylet only slightly curved and either armed or unarmed. Uropods with or without freely movable terminal spine.

This is a somewhat heterogeneous cluster of genera, all monotypic. The body tends to be vermiform with a length round about eight times as great as the maximum width. The fossil *Protamphisopus wianamattensis* and the Great Lake species *Uramphisopus pearsoni* may have a rather more robust habit. All but *Eophreatoicus* have a very marked development of the huge disto-mesial process

upon the uropod which gives to these appendages a tri-radiate appearance like that of some Cymothoidea. In all, the loss of coupling hooks upon the pleopods serves to separate them from the preceding groups, but *Synamphisopus* and *Eophreatoicus* still retain the two-jointed uropodal rami; the latter, too, retains the large prominent eye which has undergone reduction in all of the other genera. In *Eophreatoicus* and *Uramphisopus* there is retained something of a produced telsonic apex, in the latter genus this being closely like that of the Great Lake species *brevicaudatus*, while *Eophreatoicus* is unique in this sub-order in retaining epipodites on four of the five pleopods.

The distribution is interesting: *Eophreatoicus*, an isolated species from Northern Tropical Australia; *Phreatoicopsis* from the Grampians, and the Otways *Synamphisopus*, also, from the Grampians. Both of these areas are of Jurassic age and may have been colonized by Phreatoicids in Cretaceous or earlier times. *Uramphisopus* apparently lives in the muddy floor of the Great Lake, Tasmania, an even older area geologically. It has been taken only on three occasions, in every case from the stomach of a trout, and the female is unknown. The fossil *wianamattensis* is of upper Triassic age and in all probability has a kinship with *Amphisopus*. It is with some hesitation included in this sub-family

Synamphisopus, gen. n.

Body scale-clad, slender, sub-cylindrical, its surface practically free from setae. Eyes relatively small, pyriform. Head long with well-developed sub-ocular incisure, without cervical groove, completely united with first peraeon segment; peraeon rather wider than deep, first segment relatively long and very widely expanded at its ventral edge; pleon a little shorter than peraeon, the depth greater than the width. Telson with median dorsal and paired lateral ridges; without terminal projection but hinder border set with stout spines, bounding a large distinctly flattened posterior surface.

Antennule short, scarcely filiform; antenna long; maxillula, inner endite with five setospines not wholly terminal in position, outer endite with an unusually large number of spine-teeth. Maxilla with broad proximal endite, inner distal endite much shorter and narrower than outer. Maxilliped with both coxa and carpus long, and basis relatively short. Coxae of all peraeopods firmly united with their related segments; gnathopod stout, unlike in male and female, dactyl strong and very heavily setose; fourth peraeopod scarcely prehensile, dactyl small; bases of hinder peraeopods moderately expanded; ischia long. In the female, vestiges of oostegite on fifth peraeon segment. Pleopods relatively long as compared with pleura of related segments; anterior face of exopodites setose; coupling hooks wanting; uropods with short peduncle, inner distal angle greatly produced; rami bluntly truncated, armed with strong movable terminal spine, stout toothed spine beneath insertion of rami.

Genotype. *Synamphisopus ambiguus* (Sheard).

This new genus is proposed for a single species which, while presenting a number of primitive characters, seems to occupy a position almost exactly intermediate between *Phreatoicopsis* and *Amphisopus*. It was originally assigned by Sheard (1936) to *Amphisopus*, but it differs from the species of that genus in a number of important characters, in many of which it comes nearer to *Phreatoicopsis*. From that, too, it is barred by the possession of equally distinctive features. The length of the head, the reduction of the eyes, the condition of the maxilliped, the short peduncle of the uropod and especially the absence of coupling hooks on the

pleopods and the character of the typhlosole are all features in which it is akin to *Phreatoicopsis* and markedly different from *Amphisopus*. On the other hand, there are to be noted: the ventral expansion of first peraeon segment, the condition of the tailpiece, gnathopods unlike in the two sexes, a slight development of prehensility on the fourth peraeopod of the male, the expanded bases of the hinder peraeopoda and, particularly, the truncated rami of the uropods with their terminal movable spine, and the *toothed* condition of the spine below the insertion of the rami. All of these are characters in which this genus differs from *Phreatoicopsis* and approaches agreement with *Amphisopus*.

In the shape and armature of the telsonic extremity and the disposition of the anal aperture, as well as in the character of the fourth peraeopod of the male, there is a condition intermediate between those that characterize the two genera. The condition of the maxilla and the maxillula and the development of a flattened hinder surface to the telsonic region constitute differences from both *Amphisopus* and *Phreatoicopsis*; and finally in the extraordinary setosity of the dactyl of the gnathopod there is a development recorded for no other Phreatoicid, although, curiously enough, a similar condition is found in different genera of blind or purblind Australian Gammarids.

Synamphisopus ambiguus (Sheard)

(Fig. 24)

Sheard, 1936, p. 469, figs. 1-18 *(Amphisopus ambiguus)*.

To Sheard's description of this fine species, a number of details may be added.

The *body* (fig. 24, *1s*) is more nearly linear than that of any other species, excepting only those blind forms which have become entirely modified for life in subterranean waters. It is vermiform, the body being almost parallel-sided, width being practically uniform and the length approximately eight times as great as the width.(1) The surface appears smooth and is nearly free from setae, but is uniformly scaled, this condition extending to all the appendages. It is very noticeable in the last five joints of the gnathopod. In the female, the pleon as a whole is slightly narrower than the peraeon.

In dorsal view the *head* is seen to be a little longer than wide, the width being equal to its greatest depth. The length is sub-equal to, or slightly greater than, that of the first and second peraeon segments combined. The anterior border is distinctly emarginate, the front rising quite steeply from a well-developed, slit-like, sub-ocular incisure. On its anterior surface is a stout median rostral ridge. The eyes seem small, although there are about twenty-five to twenty-eight ocelli. The sub-ocular segment is not very definite but the genal groove is deep, the cheeks swelling out below it, as in *P. terricola*. The ventro-lateral border is sinuous; it is deeply concave below in the region of the anterior mandibular fulcral process, which is particularly large; this is followed by the slightly convex line of the mandibular articulation. Behind that, it dips steeply into the post-mandibular region, then crosses that area in a ridge, cutting off a small irregular ventro-lateral area below and extending behind the mandible into a small 'posterior process'. There is no trace of a cervical groove and the head is fused behind with the first peraeon segment.

Peraeon. In length, the third, fourth, and fifth segments are sub-equal, the second and sixth slightly shorter, while the first and seventh are barely half the

(1) In these proportions agreeing nearly with *Eophreatoicus*, (male).

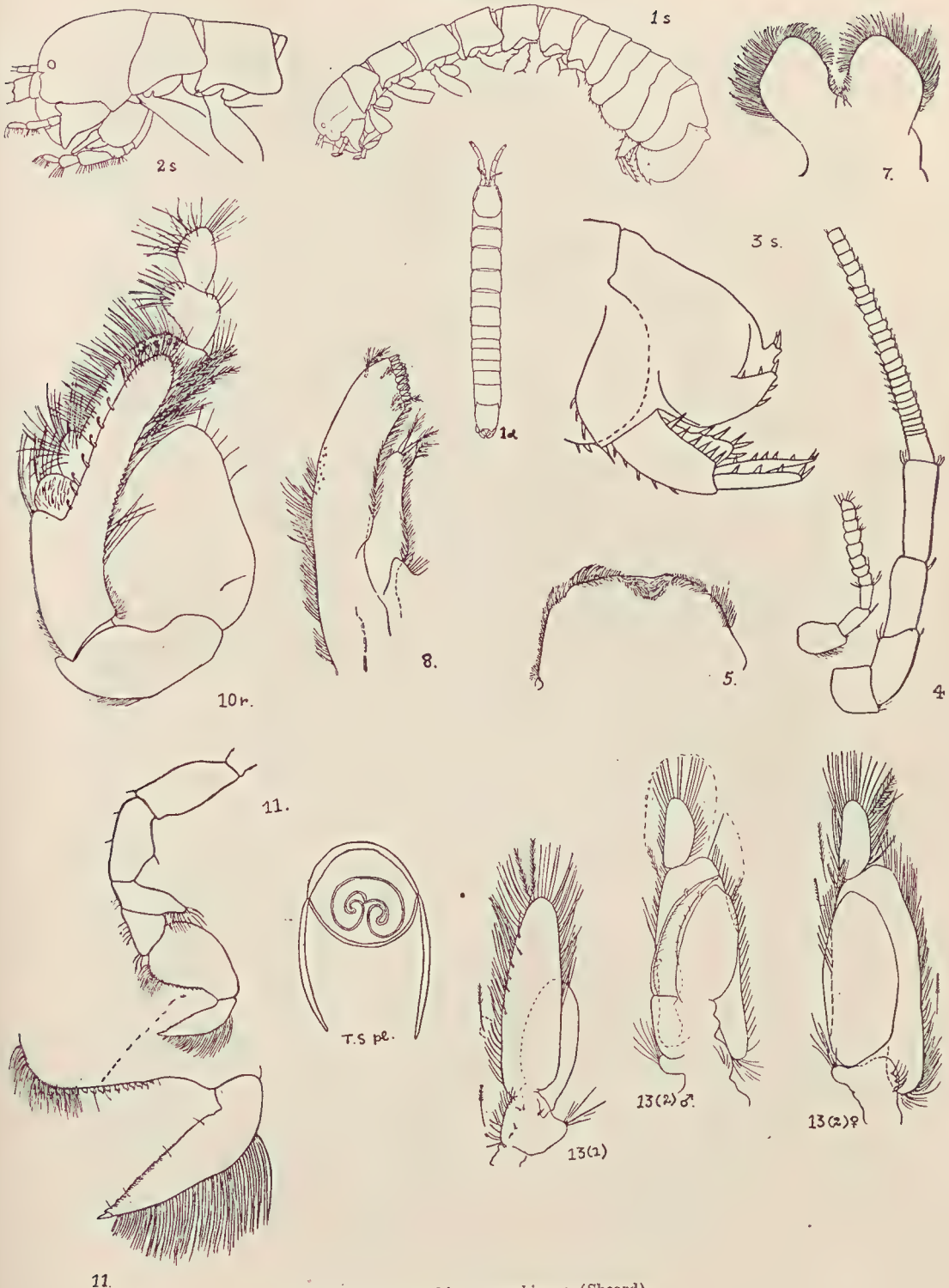


FIG. 24.—*Synamphisopus ambiguus* (Sheard).

length of the longer segments. The first segment is greatly widened ventrally to embrace slightly the postero-ventral corner of the head, its depth being considerably greater than its length. In this widened first peraeon segment, completely fused with the head and backwardly overlapping the second segment, there is an approach to the development of a carapace. The second segment appears about as deep as long, but the next succeeding segments are longer than deep; the sixth and seventh are deeper, the seventh having a depth twice its length. The pleon has a length of two-thirds only of the peraeon, being a little longer in the male; the first three segments are sub-equal, the fourth slightly longer, fifth twice as long as third and a little shorter than the tailpiece.

The pleura are fringed ventrally by slender spines, a slight notch marking the junction with the related segment in the second to fifth. In the tailpiece, the suture of the sixth segment to telson is seen at the ventral end, there being only a short ridge, which is wholly unarmed.

The telson (fig. 24, *3s*), in profile, resembles that of *Amphisopus*, there being a distinct median ridge which is not produced into a spine. It is flanked on either side by a lateral ridge which ends behind in a stout movable spine. Below, the telsonic pleuron bears a second spine, its convex border there curving anteriorly to the insertion of the uropod. The hinder surface of the telson is flattened as far down as the level of the lower pair of spines, beneath which level the ventral end of the body slopes away anteriorly, the anal opening being postero-ventral.

Anterior to the insertion of the uropods, the pleuron of the sixth pleon segment is armed with a very stout spine terminally, preceded by a series of three simple spines decreasing in size and length forwardly.

The *antennules* (fig. 24, *4*) are short and stout, but Amphisopine in character. They do not reach to the end of fourth joint of peduncle of the antenna, although there are as many as nine or ten (eight in female) joints in the flagellum, the last minute. The first joint of the peduncle is broadened laterally where it rests upon the *antenna*. This is long (two-thirds the length of the animal), the peduncle robust, especially in the male; first and second joints wide, the third with length as great as the width of preceding joints, fourth rather long, four-fifths of the fifth joint; flagellum practically twice length of peduncle, with about fifty joints. In the female, the basal joints are less wide and the proportions slightly different; the number of flagellar joints seems to vary from thirty-one to thirty-six.

Upper lip (fig. 24, *5*). Epistome with strong median ridge; labrum relatively short and wide, its ventral border only moderately convex—almost straight mesially and slightly excavated dorso-laterally where fulcral processes of mandibles abut against it.

Mandibles. These have been figured very fully (fig. 3). The left mandible, in external view, shows a large basal portion produced into distinct fulcral and acetabular prominences, the palp with first joint rather long relatively. Seen from the mesial aspect, the long, straight hinge-line forms the outer and upper border of a large aperture for the adductor muscle with its wide fan-like apodeme. The short, broad molar springs from immediately beneath this aperture and overhangs the oval spine row and doubly dentate edge. In the antero-mesial view, the spine row is found to rise on a short pedicel, which is armed by spinules and setae. The right mandible seems smaller; the inner dentate edge (lacinia mobilis) is bifid; the spine row differs somewhat; the molar is large and obliquely truncated, the first joint of palp relatively longer.

Lower lip (fig. 24, *7*) stout, inner lobes not recognizable, outer lobes sub-quadrangular, mesial edge fringed distally with setae in tufts almost concealing some eight to ten setospines.

Maxillula (fig. 24, *8*). Inner endite unusually short and narrow, its apical edge oblique and carrying five slender setospines, with which are short fine setae, but the characteristic slender spines usually accompanying these are wholly wanting. Outer endite broad and considerably larger than inner, its free surface narrow and very oblique with about thirty spine-teeth arranged in double and treble rows. On the posterior face near to the mesial edge are two short, feebly plumose, setae; more centrally, two others and sub-terminally another and much stouter plumose seta which arises barely within the lateral margin. Only exceptionally *(M. tasmaniae)* is this rank of plumose setae found so well developed in other species.

Maxilla. This appendage is remarkable, in this group, in the great reduction of the inner member of the distal endites, although there is seen a tendency in this direction in *P. terricola.* In other respects, also, the maxilla agrees more nearly with that of the latter species. In its shape the inner endite recalls the condition of *typicus* or *capensis* and differs markedly from that of either *Amphisopus* or *Phreatoicopsis.* On its inner margin very strongly developed is an anterior row of slender pectinate setae (fig. 5C, 5D, *a.s.*); behind this lies the mesial comb-like row of filtratory setae (fil.) separated by the width of the mesial surface. This ends abruptly and, at the point where this row ends, the distal part of the lobe is bent sharply mesially, producing a distinct notch. The row of setae is flanked posteriorly by the more widely-spaced pectinate setae (pct.) which form a supporting row, these setae projecting nearly at right angles, for which reason they may be made out, in permanently mounted preparations, only when examined in posterior view. Closely behind this lies the posterior row (p.r.) of fine setae. The inner of the two endites of the third segment is not only short, but is narrow and is so disposed that studied in its natural position it is to be seen only from behind. Owing to the mounting of this appendage so obliquely to the long axis, combined with the antero-posterior disposition of the joint itself, this endite lies practically mesially to and behind the outer endite. The slender pectinate setae at its apex are continued down its mesial face by stouter, more widely separated setae. Lateral to it, the large outer endite presents an inner concave face overlapping the lateral border of the proximal endite and practically hiding the anterior face of the inner distal endite. The mesial face of this outer endite, too, is armed with numerous setae, many projecting to form a stiff postero-mesial fringe, while apically a few of the terminal spine setae are very much stouter, although not comparable to the great spines found in this position in *terricola.* Well developed as this joint is, it scarcely passes the apex of the proximal endite which seems unusually large, and the whole of the distal part is thickly furred posteriorly with long, fine setae, so that the apical cluster becomes brush-like rather than a fringe.

The *maxilliped* (fig. 24, *10*) shows a greater likeness to that of *Phreatoicopsis terricola* than to that of any other species. The coxa is stout and relatively long and bears an irregularly ovate epipodite near the outer distal angle, on which are a number of short spinules interspersed with longer setae. The basis is about half as long again as the coxa but its endite is unusually stout and long, extending well beyond the middle of the carpus; the latero-distal angle of the basis bears a cluster of long, plumose setae which in other species is usually represented by one or, at most, two. The endite has the whole length of its antero-mesial edge armed with an unbroken rank of stout plumose setae (thirty or so) which pass apically (i.e., anteriorly) into a terminal tuft of mingled plumose, pectinate, and simple setae. From the apex, this cluster passes into a ventro-mesial fringe of pectinate setae, the seven hinder members of this series becoming

sub-marginal and transformed into coupling hooks. The ventral (mesial) border of the distal four joints of the palp are set with a continuous fringe of long setae, that on the last two joints being exceptionally well developed. The propod is markedly produced mesio-distally (a condition seen equally well developed only in *Phreatoicopsis*, and recalling the endites of ischium and merus in *Mysis*). In addition to these bordering fringes, the distal end of each joint bears a terminal row of setae standing out stiffly perpendicularly from the segments and the carpus appears to be widened to a mesial face, heavily furred with setae, the whole appendage having an extraordinary setose character. This condition is also seen in *P. terricola*, but in that species there are, in addition, setae standing out haphazard from all the ventral and lateral surfaces—these being wanting in *ambiguus*.

In the females examined, none show other than the incipient stage of the brood lamellae and the maxilliped has only a short outstanding crescentic lobe (without setae) springing from the mesial angle of the base of the coxa.

The gnathopod differs in the two sexes. In the male (fig. 24, *11*) the appendage has a condition intermediate between that figured by Spencer and Hall (1896) for *P. terricola* and that shown by Raff (1912) for less mature specimens. The ischium is but *little shorter than the basis* and considerably stouter; about its middle, on its anterior aspect, is a stout spine. The merus is greatly produced anteriorly and the apex of the process may have one or two spines, the process being downwardly turned, as in Raff's figure of *terricola* (1912, pl. 5, fig. 5). The propod is more nearly sub-triangular than in the case in *P. terricola* and with the palm rather more oblique and less convex. There is a rounded boss at the distal end of the palm in place of the tooth of Spencer and Hall's figure (1896, pl. 3) and the dactyl also bears a rounded elevation which fits upon a corresponding distal concavity of the palm. The proximal (slightly convex) part of the palm has a number of characteristic short pectinate spines. Another large male shows the palm more sinuous and thickly setose. In both specimens, the dactyl is much more robust and relatively shorter than in *P. terricola* and is unlike that of any other Phreatoicid in that its outer (anterior) border bears a dense fur of long setae comparable only to that found in several of the blind Australian Gammarids. Such a condition is known for no other Phreatoicid. That this is not noted in Sheard's account of the male is doubtless to be explained by the fact that dried material only was available and this had probably suffered damage to the more delicate structures. It was recorded for the female, where the condition of the several joints of the gnathopod is not unlike that figured by Sheard for the regenerated appendage in the male. It is, however, still more heavily setose than the male and the dactyl in both male and female has its inner margin finely serrated or denticulate. The ischium in the female gnathopod is more slender and the merus not so strongly produced.

In this and all the succeeding peraeopods, the coxa, though clearly defined, is apparently firmly united with its related segment.

Unlike *terricola*, however, the second, third, and fourth peraeopods show progressively the ischium decreasing in length (relatively to the basis), the merus more downwardly produced, the carpus shortening and widening. In the fourth peraeopod of the male, there is a distinct suggestion that the distal three joints may have some prehensility as in *Amphisopus*, etc.

The hinder group of peraeopods (fifth to seventh) are all longer, the basis is widely expanded, its anterior border notched and armed with spinules, its posterior border bearing short, stout spines; the ischium relatively longer. In all the peraeopods there is a secondary unguis present.

From the coxae of the seventh peraeopods arise the unusually long, strongly curved and slender penes which meet in the middle line, at the level of the distal ends of the sympodites of the first pleopods.

In the non-ovigerous female, brood lamellae are found on the first to fourth peraeopods, those on the gnathopod having the characteristically bilobed condition. The oviduct appears to open at the inner end of a raised ridge that may perhaps represent the fifth oostegite fused with its related sternite.

The *pleopods* are long, relatively to the associated pleura, so that much of the appendage is exposed. The first pleopod (fig. 24, *13(1)*) has an exopodite of lanceolate shape, bluntly rounded apically, being in this quite distinct from *P. terricola*, which it resembles, however, in the reduced size of the endopodite, which is relatively smaller even than that of *Amphisopus lintoni*. The pleopod, however, differs from that of *Amphisopus* in the complete absence of coupling hooks and the two pleopods of opposite sides are held only by entangling setae springing from a well-marked mesial process of the sympodite. The lateral margin of the sympodite extends as a flattened plate (?reduced epipodite) with abundant fringing setae. The endopodite is without setae; the expodite is fringed with setae along the distal half of its mesial border and practically the whole of the lateral border, some sixty or more of these being plumose. There are, in addition, some submarginal setae both mesially and laterally and near the apex there are numerous setae springing from the anterior face of the lamella (cf. *brevicaudatus* and *lintoni*).

In the second pleopod of the female (fig. 24, *13(2)* ♀) the endopodite is a long ovate lobe, extending nearly to the end of the proximal exopodite lobe; the distal lobe of the exopodite is a long, narrow oval bearing about forty plumose setae. The proximo-lateral lobe of the exopodite is present but does not extend so nearly to the sternite as in *Phreatoicopsis*, while the coupling lobe of the sympodite bears only two or three entangling setae.

In the male, the stout, curved penial stylet (fig. 24, *13(2)* ♂) is marked off distally from the respiratory part of the endopodite. It is distinctly of the *Amphisopine* type and without setae or spines. The basal (muscular) part of the endopodite is strongly developed.

In the hinder pleopods, the principal difference lies in the occurrence of free epipodites.

Uropods. These show a condition that is largely intermediate between that found in *Amphisopus* and *Phreatoicopsis*. The peduncle is short but, as compared with the tailpiece, much longer than in *P. terricola*. Its inner upper border is high with a number of spines and setae and produced into that strong distal process found well developed in so many burrowing forms, and, as usual, surmounted by two powerful spines. The outer upper border is much lower and slopes downwardly to the end of the peduncle, being armed with four or five longish spines. Its ventral edge bears five spines laterally rather than ventrally and these can be folded down and thus are readily overlooked. The rami, too, are longer relatively than in *Phreatoicopsis*; they are styliform and flattened dorsally and end bluntly, the upper surface of both bearing three or four movable spines, one large and one rather smaller terminating each ramus; as is so generally the case in Phreatoicids the inner ramus is distinctly the longer. Beneath the insertion of the rami is a stout spine, pectinate rather than toothed, flanked by a smaller but simpler spine.

A typhlosole (fig. 24, *T.S.pl.*) of the type recorder hitherto only in *Phreatoicopsis* is well developed in this species.

Occurrence. The Grampians, Victoria, in a creek below Fish Falls, under stones.

Colour. In spirit material pale yellowish-grey with darker marbling.

Size. Male, about 25 mm. in length. Largest female (immature), 22 mm.

Some six or seven examples of this species were collected by the late Dr. R. J. Tillyard in the summer of 1933-34, and were kindly sent to the writer for determination. They were examined and described as representing not only a new species but as requiring a new genus for their accommodation, the species being named for its discoverer; the description was, however, not published at that time, being withheld in order that it might be incorporated in the present work which even then had already largely taken shape. But in the following year specimens collected by R. V. Southcott were sent to the South Australian Museum. These, which unfortunately were preserved dry and were not very suitable for detailed investigation, supplied the material for Sheard's description. Later these, too, were sent for examination to supplement the incomplete material available, but neither collection contained mature (ovigerous) females. In the summer of 1939, an attempt was made to fill this gap, but unfortunately the season was excessively hot and dry and the collecting trip yielded nothing.

Eophreatoicus Nicholls

Nicholls, 1926, p. 190 *(Eophreatoicus).*

Body sub-cylindrical, fusiform, scale-clad, wrinkled transversely; *head* short, with slight sub-ocular incisure and strongly-developed cervical groove. Eyes large, prominent, with many ocelli; first peraeon segment of moderate length, apparently fused with head, pleon comparatively long with deep pleura, first four segments sub-equal, fifth as long as the tailpiece, terminal projection very slightly developed, not upturned.

Antennule with many-jointed flagellum, antenna moderately short with peduncle robust; mandibles short, stout, palp with joints short and broadened; gnathopod, alike in both sexes, strong, hand primitive, the straight palm occupying the entire posterior margin of propod; fourth peraeopod in the male probably with terminal *three* joints for grasping; all peraeopods with merus expanded, basis and ischium greatly expanded on fifth to seventh; pleopods with exopodite and endopodite sub-equal, without coupling hooks; first pleopod with rami long and sub-lanceolate; epipodites on second to fifth pleopods; penial stylet cylindrical, curved, armed terminally; uropod expanded; inner ramus lamellar, outer more nearly styliform, both blunt-ended with movable terminal spines; spine beneath insertion of rami simple.

Genotype. *Eophreatoicus kershawi* Nicholls.

Eophreatoicus kershawi Nicholls

(Fig. 25).

Nicholls, 1926, p. 190, figs 17-39 *(E. kershawi).*

Body robust, sub-cylindrical, having through the peraeon and part of pleon a nearly uniform width which is rather greater than the depth (as 5 : 4). The head is slightly narrower and, behind, the pleon tapers gently from the third segment, the body being sub-fusiform, its length in the male being nearly eight times its greatest width, as in *Synamphisopus.* In the female, the peraeon is markedly

broadened, so that the greatest width is a little more than one-fifth of the total length. The surface is everywhere scale-covered and with fine setae sparsely scattered; in the peraeon and part of the pleon there are low transverse wrinklings.

The *head* is scarcely longer than the third peraeon segment, considerably shorter than the combined length of first and second segments. In profile it appears almost as a quadrant of a circle, rising steeply in front. The eyes are exceptionally large, sub-circular and very prominent, having about one hundred ocelli. A sub-ocular incisure is barely indicated by a shallow groove.(1) The anterior border of the head is distinctly emarginate, above a narrow vertical rostral ridge; the interocular space wide, although little more than once and a half the greatest diameter of the eye. Its ventro-lateral border, nearly horizontal anteriorly, bends gently downwards into the post-mandibular region. Arising from the posterior border, a deep cervical groove marks off incompletely the maxilliped segment behind which the first peraeon segment is forwardly produced to embrace the head with which it is firmly united.

The *peraeon* appears compressed, but is actually slightly wider than deep (5 : 4) in the male; in the female, the greatest width may be almost twice the depth. The second, third, and fourth peraeon segments are sub-equal; fifth, sixth, and seventh decreasing progressively in length, the seventh sub-equal to the first. This first segment is turned forwardly at its lower end to overlap slightly the hinder lower corner of the head, but the segment is not noticeably widened below, thus differing markedly from *Amphisopus*, *Synamphisopus*, and *Phreatomerus*, but resembling *Phreatoicopsis* and *Mesamphisopus*. The coxal plates are small, the hinder three not entirely marked off from their related segments.

The *pleon* is relatively long, almost equalling the peraeon, the first segment sub-equal to the first peraeon segment, second, third, and fourth progressively longer, fifth as long as combined length of third and fourth and sub-equal to tailpiece.

The pleura are deep, the fourth segment having a depth three times its length; that of the fifth segment is shallower and meets its segment at a sharp angle posteriorly. In a mounted preparation of all these pleura, there is to be seen a dark line (probably a thickening of the chitin) at the level where pleuron and tergum meet (fig. 25, *pl. 3*, *pl. 4*). In the second, however, there is a distinct fold in this region suggesting that the pleuron is an epimeron (prae-coxa) which has become sutured to its segment, this condition being closely comparable to that existing in the peraeon of those forms in which the coxae are firmly fused with the related segments.(2) The ventral margins of these pleura are armed with a few widely spaced spinules, which occur only around the curved lower part and are not developed upon the posterior borders.

In all these segments, there are slightly developed transverse wrinklings, scarcely to be called ridges, and if a portion of the lateral surface be examined under a high magnification, the uniformly scaled condition is seen to bear broken transverse lines of sparse and minute spinules in vertical rows, each row apparently marking the line of a ridge.

In the tailpiece, the distinction between sixth segment and telson is very slightly indicated; dorsally, perhaps, by a little-developed crest running transversely and forwardly, parallel to the hinder border of the piece, near its posterior

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(1) A condition approached by *Phreatoicopsis* and *Synamphisopus*.

(2) It is of interest, in this connection, that in several of the specimens of the fossil *wianamattensis*, the pleura were apparently readily disconnected from the related terga (Chilton, 1917, figs 3 and 4).

end,[1] and ventrally by a short ridge directed antero-dorsally from the insertion of the uropod. Under low magnification, this ridge appears unarmed, but, more highly magnified, is found to represent a continuous line of short, stout spinules. The significance of these spinules is obvious when it is noted that such a line of spinules arms the posterior pleural edge of the telson and that a comparable series is found along the borders of the hinder peraeopods (fig. 25, *p.mr.*). It is very probably indicative of an originally free edge, in this case the hinder margin of the sixth pleon segment. The terminal projection is but a rounded oblong knob, flattened below and armed with four stout spinules and several setae. It is flanked on either side by a stout movable spine capping a strong projection, evidently the postero-dorsal end of the related pleuron; more ventrally, a similar but smaller spine occurs, the profile of this telsonic pleuron being strikingly like that of *A. lintoni*. There is, however, a narrow flattened posterior surface which is not found in that genus, but is better developed in *Mesamphisopus*, *Uramphisopus*, and some of the Phreatoicine forms.

Anterior to the insertion of the uropod, the pleuron of the sixth segment (fig. 25, *pl. 6*) bears a very stout, simple spine posteriorly, flanked mesially by a stout spine, toothed apically and preceded by a series of ten or eleven similarly toothed spines decreasing progressively in size until the uppermost is a slender spinule lying wholly sub-marginally. The anterior margin passes upwards almost vertically, so that the tailpiece is very short below (antero-posterior measurement) and resembles, rather closely, the corresponding region of *Phreatoicopsis*.

Appendages. These are described rather fully in the original account (1926), but there remain numerous details which were overlooked or the significance of which was not, at that time, sufficiently appreciated.

The *antennule* reaches to the end of the second joint of flagellum of the antenna. The peduncle, which is a little shorter than the flagellum, is not well defined and may be followed by as many as sixteen joints; the first (sometimes, also, the second) flagellar joint resembling the third joint of peduncle, except for size; the succeeding joints are short and sub-rectangular, many bearing sensory setae which differ from the usual 'olfactory cylinders' of this sub-order; the terminal joint is a small knob. The generally scaled condition gives to the outline of the joints a serrated appearance (fig. 25, *4*).

Antenna, moderately short, less than one-third of the length of the body with first and second joints of peduncle stout and sub-equal, the third slightly longer, but its length less than the width of the proximal joints, while the fourth is just as long as their width. The fifth joint, more slender, is twice the length of the fourth joint and the whole peduncle is shorter than the flagellum which is sub-equal in length to the first antenna. Twenty joints were counted in a flagellum not quite complete, the serrated appearance of the joints being very noticeable.

The *labrum* (fig. 25, *5*) is, as usual, asymmetrical, its lower border convex and heavily setose.

Mandibles. The left mandible (fig. 25, *6*) has the primary cutting edge of four stout teeth, the lacinia mobilis three, nearly as stout; the spine row with eight or nine pairs of stiff curved pectinate spines; dorsal to the palp, the mandible bears a low conical fulcral process; the elongated molar has about four setae arising from the dorsal edge of its tuberculate surface, a condition seen in many Amphipoda; immediately posterior, there is the huge adductor muscle, the lower border of the muscle exit being practically straight and edged with the spinules so characteristic of this species; the palp has the proximal joint short and stout,

[1] Cf. *M. tasmaniae*, *Amphisopus*, and *Synamphisopus*.

carrying four spines sub-terminally, the second joint, more than twice the length of the first, is flattened, a broad sub-oval in shape, about fourteen spines arming its dorsal edge and its end; terminal joint, as short as or even shorter than the first, is also broadened, the distal part of the ventral edge having about fourteen stiff setae, of which the two terminal are very long. A stout spine arises from the mandible just posterior to the attachment of the palp.

The *right mandible*, also, has four teeth on a stout primary cutting edge; the lacinia mobilis is more slender, its teeth appear more numerous and are minutely denticulated; the molar is longer, obliquely set, its apex having five longish setae and two shorter curved pectinate spinelets. The hinder end ('acetabular process') of the mandible is somewhat concave, evidently fitting upon an elevated area in the post-mandibular region. In the palp the second joint has about twenty stout spines on the distal three-fourths of its dorsal border.

The *lower lip* (fig. 25, *7*) shows no inner lobe. The rounded apex of the sub-quadrangular outer lobe is fringed with stiff curved setae, many of which appear to spring in tufts from a central axis (setospines) comparable to the penicilla found in mouth parts of terrestrial Isopoda.

The *maxillula* (fig. 25, *8*) is comparatively stout; the inner endite is broad, its apex somewhat oblique and bearing eight setospines with two simple spines, lying adjacent to the first and third of the apical series. The outer endite is rather longer and distinctly more stout, has about fourteen spine teeth in two (in places, three) parallel rows; the outermost are simple, the more mesial are denticulate on two sides while one near the mesial edge is a plumose spine unusually long although shorter and less plumed than those on the inner endite. On the same (posterior) face of the endite, sub-terminal in position, are a couple of slender plumose setae.

Maxilla (fig. 25, *9*). The proximal endite has an almost straight mesial border, being without the distal bend. Its anterior mesial edge bears sub-marginally a dense fringe o ffine setae; the posterior edge has the usual continuous comb-like rank of filter setae which runs to the apex and passes into the terminal brush. Behind this is the more open row of pectinate setae springing well in from the margin. These, too, stretch practically the whole length of the endite and curving at the apex form the posterior part of the distal brush, among which are simple, pectinate (or biting) and many plumose setae. Farther still from the margin and parallel to the other series of setae is a dense fringe of fine hair-like setae. The arrangement of setal rows closely parallels that recorded for *Synamphisopus*, in which, however, the mesial surface between anterior and posterior edges is particularly wide. The endites of the third segment extend distally considerably beyond the proximal endite; they bear apically and on the mesial faces of both a large number of long and stiff biting setae, while buried among the apical brushes are two very stout spines on the inner and one on the outer endite—very like those described in *Phreatoicopsis*. It seems probable that these proportions of the endites are primitive, the shortness of the outer endites in *Synamphisopus* being due to reduction.

In the *maxilliped*, the coxa is stout but, as compared with the basis, not particularly long; it is extended laterally supporting the epipodite. This is sub-circular and short, reaching only to the distal end of the main sub-oblong part of the basis. Part of its outer surface is crenate, the indentations bearing each a short spinule. The endite of the basis is a long, slender structure appearing lingulate in mesial view and is fringed along the whole length of its dorsal edge

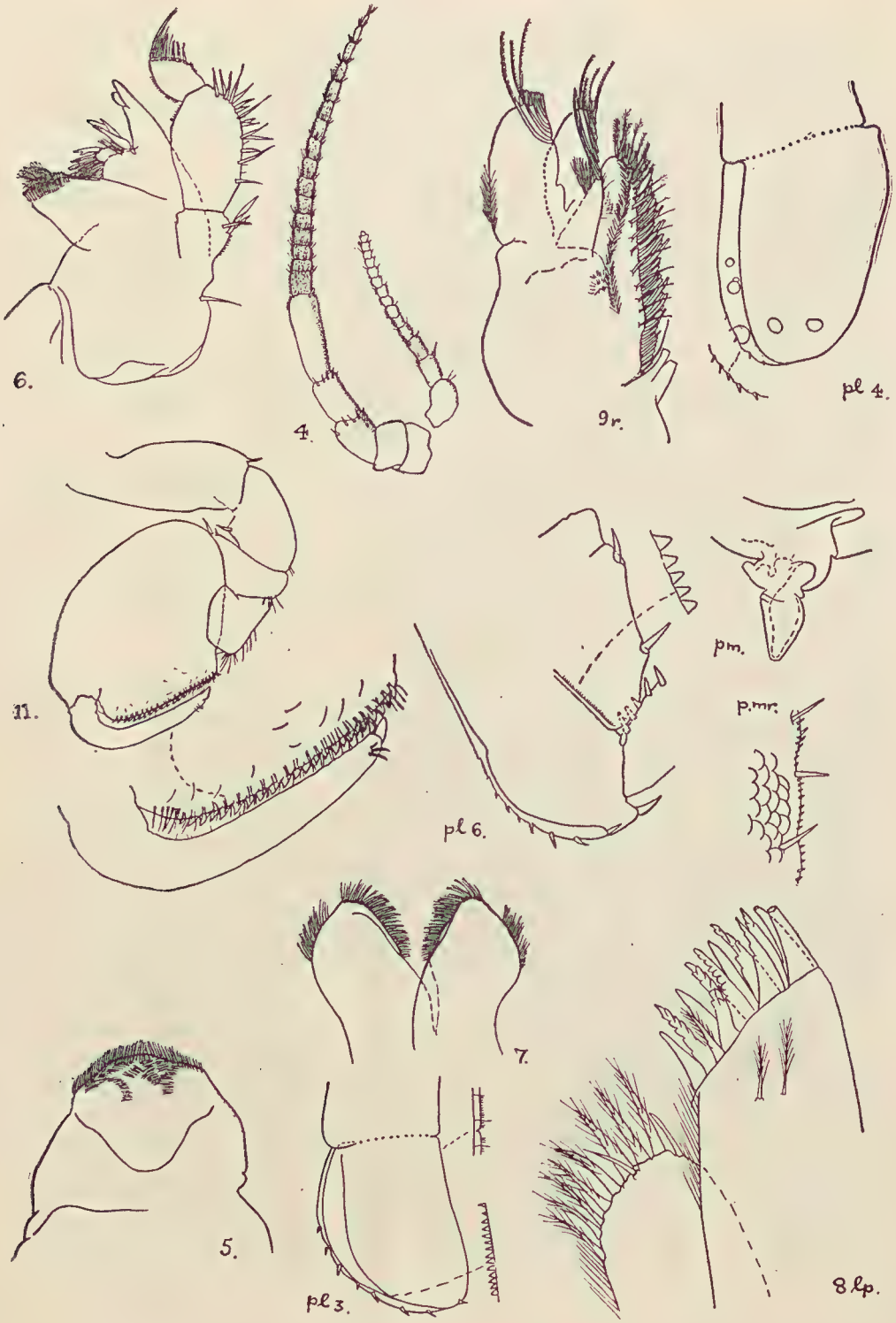

FIG. 25. – *Eophreatoicus kershawi* Nicholls.

with stout plumose setae, replaced at the apex by pectinate setae. It reaches distally mid-way along the carpus and bears on its mesial surface four stout barbed coupling hooks, and is clothed apically with the usual brush of simple, pectinate and plumose setae. The disto-lateral angle of the basis bears a couple of stout plumose spines, as in *Amphisopus*. The propod is flattened, sub-circular, the dactyl sub-oblong; the inner borders of the distal three joints are heavily setose.

The *gnathopod* (fig. 25, *11*) is notable for the relative shortness of the ischium; the merus is produced anteriorly into a truncated conical process, armed like that of *Phreatoicopsis* and *Synamphisopus* with one very stout spine; the proximal border of the propod is sinuous, being excavated by the carpus. The propod is very massive, as broad as long and correspondingly thick; the palm, which occupies almost the whole posterior border of the joint, is practically straight and is armed with the characteristic spine-teeth which are particularly well developed proximally, the dactyl is stout, has developed a sharp bend near its insertion and then is straight, lying parallel to the palm.

The succeeding three peraeopods show two features which are without parallel among living Phreatoicids: (1) The antero-proximal angle of the bases of second to fourth peraeopods is produced into a short stout process crowned with a tuft of stiff spine-setae; these are the more conspicuous because the remainder of the surface of the joint is practically unarmed. It seems altogether probable that these elevations represent the last vestiges of the vanished exopodites of these limbs. It will be recalled that in some Anisopoda and Cumacea, exopodites are variably developed or wanting on these appendages. In several species of the more primitive Amphisopine genera, traces of this structure are seen, but in none of these does it attain the development found in this species. (2) The other feature peculiar to this genus is the large degree of *anterior* expansion of certain of the joints (particularly basis,[1] ischium, and merus) of these three peraeopods, and the posterior expansion of ischium and merus, as well as of basis in the fifth to seventh peraeopods. This condition is approached elsewhere, among the Phreatoicidae, only in the fossil species *wianamattensis*, and, less evidently, in *Synamphisopus*. The length of the fifth peraeopod is less, rather than greater, than that of second or third; while the sixth and seventh are considerably longer (at least one-third). In all three of these limbs of the hinder group, the ischium and merus bears a powerful spine postero-distally; the more distal joints bear a number of spinules and spines but the basis is almost without setae, its thin membranous expansion being feebly crenate behind, each of the indentations bearing a short setule which may be feebly ciliated. The dactyl is, in all the peraeopods, supported by a small secondary unguis.

The *pleopods*, too, retain several primitive features not occurring in other extant forms. First pleopod has broad sub-oval and sub-equal lamellae springing from a wide and stout sympodite, on the lateral aspect of which there is a widely-expanded membrane (1926, pl. 27, fig. 24), armed with a fringe of setae, which suggests a reduced epipodite fused with the sympodite. Mesially, another widely expanded lobe bears the entangling setae. These are arranged in two tufts, one proximally and the second apically. Laterally, the exopodite is produced into a proximal lobe lying behind the reduced epipodite; its outer border for half its length is fringed with simple setae which are replaced, in the distal half, by plumose setae, continued around the apex for the distal fourth of the mesial border.

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[1] The basis of first to fourth peraeon appendages has a comparable anterior expansion in *Paramphisopus*.

Here, the plumose setae are discontinued and the mesial border is free from setae of any kind. Laterally and apically, a few simple setae are sprinkled sub-marginally. The endopodite is bare of setae, although a rare crenation of its margin suggests that setae originally fringed this lamella as they still do in *Mesamphisopus*, *Notamphisopus*, and *Hypsimetopus*.

It is in the second pleopod that this species exhibits the most striking peculiarities. In general, it resembles most nearly the second pleopod of *littoralis*, but from this, and, indeed, from all living Phreatoicids, it differs in that it retains a free epipodite. This is large, an elongate reniform in shape, with relatively few simple setae. The coupling lobe is produced mesially and bears a single tuft of numerous entangling setae. On the exopodite, plumose setae are restricted laterally to the distal half of the proximal lobe and the outer border of the small sub-circular distal lobe. Mesially, this distal lobe has simple setae only and these continue on to the proximal lobe, forming a dense fur of fine, stiff setae marginally and sub-marginally for about one-third of the mesial border. Proximally, the exopodite is produced both laterally and mesially, almost completely hiding the anterior face of the sympodite. The endopodite is sub-equal to the proximal lobe of the exopodite and, in the male, bears a long, curved, cylindrical penial stylet (1926, pl. 27, fig. 26). This, too, differs from that of all other known species in the degree of development of its terminal armature of numerous (about thirteen) stiff setae. The fringing setae along its inrolled free edges are also more numerous than in other species, the condition in *Mesamphisopus* perhaps most closely approaching it.

The sternite of this second pleon segment bears mesially, between the pleopods, a curious structure whose function is not obvious (fig. 25, *pm.*). In its appearance, there is something suggestive of a small *petasma* (cf. *Leucifer*). The only preparation examined, in which it appears, is one in which the pair of pleopods were removed together with the intervening sternite. It is not certain, therefore, whether it is of constant occurrence in this genus.

Third to fifth pleopods differ, as in practically all the members of this sub-order, in shape and relative proportions of exopodite and endopodite. The epipodite is large and sub-quadrangular, but in the fifth it is almost sub-triangular. The other lamellae become increasingly shorter and wider, but the endopodite retains its general sub-equality to the proximal lobe of the exopodite, the coupling lobe increases in size.

The *uropods*. These are stout and comparatively short, the length of the peduncle (measured along its ventral border) being only about twice as great as its depth at its attachment. The inner border of the peduncle is raised into a high and thin membranous lamella armed with ten to a dozen spines of various sizes, the two largest being sub-terminal. The outer border is low and bears about four spines which increase in size posteriorly. The inner and larger ramus is a thin lamellar structure, fringed nearly continuously with spines of varying sizes and ends bluntly with one large terminal spine and a second sub-terminal. The outer ramus is more nearly styliform and shorter by one-fourth of its length, bears fewer spines, two being terminal and sub-terminal. Beneath the insertion of the rami is one large and strong simple spine, flanked by another similar but much smaller.

Occurrence. This species has been taken once only, by W. M'Lennan (Nov., 1915) at Sandstone Bluff in Arnhem Land, Northern Territory. In a letter received from Mr. Kershaw, it was explained that the 'water hole' was in all

probability in the Sandstone Ranges, near the King River about 90 miles east of Port Essington. M'Lennan's diary, edited by Captain H. L. White and published in 'The Emu' (vol. 16, 1917, p. 138) gives some further details concerning the difficult nature of this region. About a hundred specimens were taken (M'Lennan, 23.11.15), of which about three-fourth were male; no mature females were represented in the collection.

Size. Males in length from 12 to 21 mm., width 2·5 mm.; immature females may reach a length of 14 mm. and a width of 3·5 mm.

Colour. In spirit, yellowish grey with dendritic spots variably abundant which occasionally unite to form dark bands.

In the sum total of its characters *Eophreatoicus kershawi* probably retains most nearly the primitive Amphisopine *facies*, although in many of its features it may have become specialized.

In all probability the following characters are primitive, (i) the general proportion of the body, its marked scaliness and the retention of transverse ridges; (ii) the well-developed filiform antennule, the relatively short antennae and the prominent, multi-facetted eyes and conspicuous cervical groove; (iii) the condition of the mouth parts; (iv) the simply sub-chelate character of the hand of the gnathopod, involving the whole posterior border of the propod as a palm and the retention of possible exopodite vestiges on the bases of the anterior peraeopods; the expansion of the bases of all the peraeopods, the shortness of the ischium and the expansion of this joint and the merus; (v) in the pleopods the outstanding character is the retention of an epipodite on the second pleopod; the penial stylet long, cylindrical, and strongly armed (the typical Amphisopine tapering unarmed stylet probably being a derived condition); (vi) on the tailpiece, the short upturned telsonic surface, and in the uropods the lamellar rami, multi-spined and with freely-movable terminal spine or second joint.

The stout, simple spine beneath the insertion of the uropod rami is, also, probably primitive. It may be supposed to have co-existed with one or more toothed spines, which in most Amphisopine forms have disappeared, while the simple spine has persisted. In the Phreatoicine forms and in *Amphisopus* and *Synamphisopus* it is the simple spine which has gone.

The condition of the typhlosole was unfortunately not noted.

Of possible specializations several may be instanced:—(i) the shortness of the first peraeon segment, but this may well have been a feature of the ancestral Peracaridan, and the length of this segment (e.g., *P. typicus, M. capensis*) a secondary acquisition—its extreme elongation (*Phreatoicoides* and *Hypsimetopus*) is almost certainly a modification associated with the development of a vermiform body in adaptation to life in water-filled, subterranean crevices. In any case one subterranean species *(H. plumosus)* exhibits a short first segment, probably a case of retention of a primitive condition; (ii) the shortness of the coxa in the maxilliped; (iii) the reduction of the coxa and the fusion of this with the tergum in the three hinder peraeopods; (iv) the absence of coupling hooks from the sympodite of the pleopods.

Protamphisopus, gen. n.

Entire animal appearing compressed; head insufficiently known, peraeon with segments much deeper than long, some with a marked transverse ridge; transition to pleon abrupt, the pleon segments being strongly downwardly produced; first

segment shortest, second to fourth sub-equal in length, fifth about equalling combined length of third and fourth; sixth partly marked off from tailpiece, which is little longer than fifth, telson probably not produced into terminal projection.

Antennule stout, multi-jointed; eyes not known.

Basis well expanded in at least the last five peraeopoda, ischia relatively shorter than in any extant form; gnathopod probably with massive propod; merus strongly downwardly produced in third and fourth peraeopods; third to sixth peraeopods apparently sub-equal, seventh rather longer, dactyl very long in hinder three peraeopoda.

Uropod very short, peduncle short and widening distally, rami short, sub-equal.

Genotype. *Protamphisopus wianamattensis* (Chilton).

Such characters as are to be made out in these fossils are for the most part not those on which is based the present division of the Phreatoicids into families. Nevertheless, the general facies is so like that of *Eophreatoicus*, *Phreatoicopsis*, and *Amphisopus*, and so unlike that of the Bassian sub-alpine species that it is extremely probable that it is correctly assigned to the *Amphisopidae*.

In the shortness of the ischia it is more distinctly Amphipod-like than any extant form;[1] the unusual degree of production of the peraeon segments might possibly have been attributed to a larger (epimera-like) development of the coxae of the anterior peraeopods were it not the typical Phreatoicid coxae are to be made out in some of the remains (Chilton, 1918, fig. 6, p. 376, and fig. 8, p. 377). The shortness of the uropod and the abruptly-ending tailpiece are in marked agreement with *Phreatoicopsis*. The expansion of the basis, the downward extension of the merus[2] on the anterior peraeopods, the proportion of peduncle and rami of uropods, the rugosity of peraeon segments, are all features found in *Eophreatoicus*. The appendage identified by Chilton (1917, p. 378, fig. 10) as the antenna is, also robust and short as is the case in many Amphisopine forms (cf. *Phreatomerus latipes*, 1922, p. 27, fig. 1), but it may equally well have been an antennule which, too, is a relatively stout appendage, and in that case would be relatively long and multi-jointed. The near uniformity in the length of the peraeopods is probably primitive (cf. *Acanthotelson*), but the expansion of the basis was doubtless associated with an active swimming habit and may be assumed to have been derived quite independently of any Amphipod relationship. It is exceeded in the existing *P. latipes* from Central Australia.

A specimen, provided by Dr. Tillyard and apparently one which was not seen by Chilton, reveals the dorsal surface (text fig. 26B). It seems to have had a length not greater, and probably less than, six times its maximum width, which suggests a short sub-depressed animal.[3] It is possible, however, that the remains are those of a female, and would then have much the same proportions as those of *E. kershawi*. The more anterior, at least, of the peraeon segments were apparently raised into one or, in some cases, two transverse ridges, a feature still preserved in some extant forms. These are shown, also, in one of Chilton's figures (fig. 8, p. 377), although attention was not directed to them.

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(1) Chilton (1892) was apparently the first to call attention to the fact that in Amphipods this joint is normally short, whereas in Isopods it is relatively long, and he uses that fact as supporting his view of the distinctness of the Phreatoicids from the Amphipoda. It is, therefore, of considerable interest that in the Triassic form this joint was exceptionally short! It may be noted, too, that this joint is short in the Apseudidae with which group the Phreatoicoidea have many features in common.

(2) A produced merus occurs also in *P. latipes*, a detail which Chilton's figures (1922, figs 8 and 9) fail to show.

(3) It must be borne in mind, however, that the specimen may have been somewhat crushed and so suggest a width greater than was actually found in life.

In this latter figure are possibly represented the second to seventh peraeon and first pleon segments, rather than last five and first two pleon segments as Chilton considered.

In one appendage, apparently the fourth peraeopod, Chilton figures (l.c., p. 378, fig. 10) a rounded boss on the proximal end of the basis. It is of interest that just such a knob is well developed in this position in Eophreatoicus and represented perhaps in *A. lintoni* and *Uramphisopus* by a well-developed tuft of spines or setae.

Protamphisopus wianamattensis (Chilton)

(Fig. 26)

Chilton, 1918, p. 365 *(Phreatoicus wianamattensis).*
Calman, 1918, p. 277 *(Phreatoicus wianamattensis).*
Sheppard, 1927, p. 112 *(Phreatoicus wianamattensis).*
Barnard, 1927, p. 161 *(Phreatoicus wianamattensis).*

With the characters of the genus.

None of the specimens described by Chilton show a modified fourth preaeopod. While this is possibly due to the fact that all specimens seen were females, it being not unusual to find a great disproportion in the number of the sexes,[1] it seems more probable that, at that stage in evolution, this modification had not come into existence. Even among extant forms this peraeopod remains unmodified in *Paramphisopus, Phreatomerus,* and *Phreatoicopsis.*

Concerning the gnathopod, it is found that in those species with massive propod, this limb tends to become detached at an early stage of maceration, whereas less bulky peraeopods usually remain attached. Since in none, apparently, of these fossils is this first peraeopod preserved the explanation may well be that the gnathopod had, even at that remote period, already undergone considerable development.

While there is perhaps insufficient warrant for the erection of a new genus for this fossil species, of which so very little is certainly known, it is difficult to find as much justification for its assignment to any extant genus and particularly to *Phreatoicus,* proposed, as that genus originally was, to receive an extremely specialized subterranean species.

In its general appearance (fig. 26) it seems to have been a blend of *Eophreatoicus kershawi, Phreatoicopsis terricola,* and *Phreatomerus latipes*; indeed the external features of Amphisopine forms are as much in evidence in this species as in any living form. The fact of its great antiquity renders it unlikely that it would have already lost the lacinia mobilis from the right mandible preserved by so many species or even the second pair of epipodites still retained in one present-day species *(E. kershawi),* unless we are to assume that this latter is a relic even more ancient. A feature on which Chilton relies to disprove the Amphipodan relationship to Phreatoicids (viz., the relative length of the ischium in the latter) is in this species least evident; indeed, the proportions of ischium and basis are much as in Talitrids. It is rather surprising that Chilton, in his account of this fossil, did not note that fact, since, in stressing its likeness to *australis,* he called attention to the fact that the *habitus* figure (1918, fig. 13a) of the latter species

[1] Chilton notes that of *typicus* he had no males, and in *Amphisopus* it has been the writer's experience that females are enormously in the preponderance. On the other hand, of *assimilis,* Chilton records but one female; of *Eophreatoicus* about 75% and of *Hyperoedesipus* probably 90% are males; and Spencer and Hall record that in the batch of *Phreatoicopsis* sent them there were no females, while in the collection of *U. pearsoni* no females were seen in nearly a hundred specimens.

was not wholly correct in respect to the peraeopods, because the ischium is shown as relatively too short; accordingly he gave enlarged figures of third and seventh peraeopods, in which (as he stated) the proportion of the joints was more correctly displayed and in these, the ischia are seen as approximately two-thirds of the length of the bases, whereas in *wianamattensis*, this joint, where well preserved, rarely appears to exceed one-third of the basis. A relative shortness of this joint is a feature also of *Eophreatoicus*, as is, too, the anterior expansion of the merus, although in the extant genus neither of these features is retained in as pronounced a manner as in *wianamattensis*.

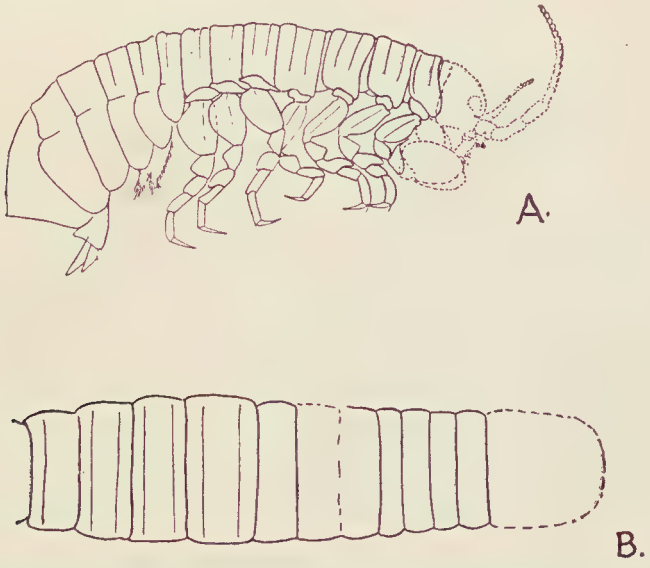

FIG 26.—*Protamphisopus wianamattensis* (Chilton). (A, restoration; B, part of dorsal view.)

There seems to be nothing, in the writer's opinion, in the shape of the telson which in the least recalls the condition found in *tasmaniae*, as Chilton has suggested (1918, p. 375); much more obviously it resembles the truncated end of *P. terricola* or *S. ambiguus*, while the uropods are surprisingly like those of *P. terricola* or *U. pearsoni*.

The proportionate depth of the peraeon segments is more like that of a generalized Amphipod than the condition found in *A. lintoni*, which is, of existing species, probably the most Amphipod-like. Since this earliest of known Phreatoicids had, thus, in Triassic times, a more Amphipod-like form than any of its present-day representatives, and since it was, by that vast interval of time, so much nearer to the common stock, the force of the argument in favour of kinship is the greater, while the supposition that the present-day likeness (which appears much less strong than in the past) is due to convergence, is correspondingly weakened.

Phreatoicopsis Spencer and Hall

Body scale-clad, stout, linear; peraeon semi-cylindrical (twice as wide as deep) approaching depressed; pleon but slightly compressed, pleura not deeper than related segments; tailpiece almost circular in transverse section; telsonic projection not developed.

Antennule shorter than peduncle of antenna; inner endite of maxilla with complete double row of spines and setae; coxal joints of first four peraeopods in the male, and of the first in the female, fused with the related segment; gnathopod alike in both sexes; fourth peraeopod unmodified in the male; pleopods with lamellae lanceolate, without plumose setae, the first with endopodite shorter than exopodite; sympodite lacking coupling hooks; uropod short extending little behind telson, distal end of inner border produced into strong mesial process, spine below insertion of rami stout, not terminally toothed; rami end in short points and lack freely movable terminal spine.

Typhlosole well developed, spirally inrolled, and extending practically the whole length of digestive tract.

Genotype. *Phreatoicopsis terricola* Spencer and Hall.

Phreatoicopsis terricola Spencer and Hall

(Figs 27, 28)

Spencer and Hall, 1896, p. 12, pls. 3 and 4.
Raff, J. W., 1912, p. 70, pl. 5 (part).
Nicholls, 1924, p. 98; 1926, p. 203.
Sheppard, 1927, p. 117.
Barnard, 1927, p. 160.

This, the largest living Phreatoicid, has a stout vermiform body, widening a little in mid-peraeon and thereafter tapering slightly posteriorly. There are no traces of ridges or sculpturing, but the body as a whole is scale-covered. Setae are few, short and scattered; there are a few upon the head in front of the eyes and probably a few also fringing the ventral borders of the head, for, although these are not actually seen, there is a series of minute depressions which suggest that setae or spinules had been present.

The *head* (fig. 27, *2s*) is sub-equal in length to that of first and second peraeon segments combined; as seen in profile, the front rises steeply, the dorsal line being almost straight. The emarginate anterior border is defined by a very slight ridge and upon the nearly vertical front the antennae are separated by a well-marked, long, triangular structure which suggests a vestigial rostrum (a similar development is found in *P. latipes*, while in *capensis* the ventral end persists as a ridge). The sub-ocular incisure is a narrow notch followed by a groove which is continued into the well-marked genal groove. Below the incisure, a sub-ocular area is outlined, its lower boundary being traceable onto the ventral surface. Spencer and Hall, in their *habitus* figure (l.c., pl. 3), depict below this a small but distinct triangular area which is actually a ventro-lateral part of the sub-ocular region. It overlies and extends forwardly beyond the fulcral process of the mandible. Behind the sub-ocular region, the ventro-lateral region of the head (which appears unarmed) is represented by a very narrow, smooth area immediately above the mandibular articulation; behind this the borders turns downward and widens into a deep post-mandibular extension of the gena which is very prominent in this species. In the figure by Spencer and Hall, the ventro-lateral border is incorrectly shown as a sinuous but practically horizontal line. Actually, the genal surface dips downwardly behind the mandible and is partly hidden by the overlying epipodite of the maxilliped. This condition is quite unusual, for, in Phreatoicids generally, this post-mandibular area is separated from the genal by a definite ventro-lateral ridge; in *P. terricola*, it differs, too, in that a deep slot is developed

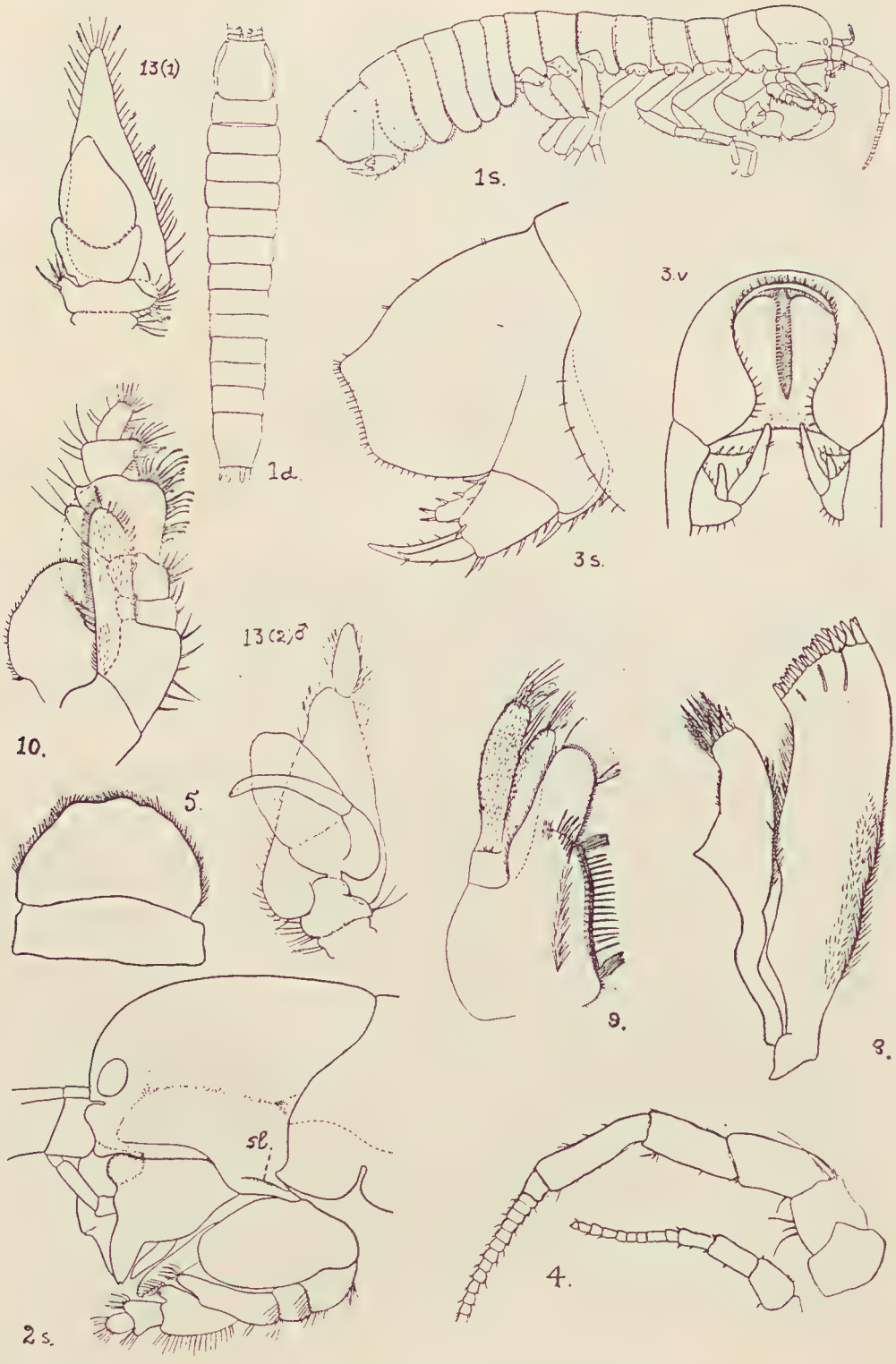

FIG. 27.—*Phreatoicopsis terricola* Spencer and Hall.

N.B.—The dark mesial border of proximal endite (9) represents the close set rank of bases of filtratory setae.

to receive the upper, lateral border of the epipodite of the maxilliped. In the figure the epipodite has been displaced, to expose this slit. The posterior region of the head shows no vestige of the cervical groove, the first peraeon segment having a somewhat sinuous anterior border which overlies the head, particularly at its ventral end, and is firmly united with it. The antero-ventral angle of the fused coxa projects in a rounded corner upon the head above the slot on the gena. The eyes, in comparison with the size of the animal, are small but are conspicuous as black sub-oval bodies on the dull cream-coloured head. There are from forty to forty-five ocelli, but the eye does not project prominently. In a freshly-killed specimen (a large male), examined under strong illumination, the eye appeared as a number (forty-four or forty-five) of mirror-silver surfaces bounded by black rings. In long-preserved material, they become dull black and may fade almost into invisibility. Spencer and Hall, comparing them with those of *australis* (where ocelli are few) suggested that the larger number found in *P. terricola* (stated by those authors as about thirty) were correlated with its large size. Since, however, other and far smaller Phreatoicids (e.g., *Amphisopus*, spp.; *Phreatomerus latipes*, etc.) may have actually larger eyes as well as a much larger number of ocelli, it seems more probable that there has been a marked *decrease* in the importance and size of the eyes in *P. terricola* as a consequence of the adoption of the cryptozoic and partly subterranean mode of life.

Peraeon. In its general proportions, the peraeon agrees with that of *M. tasmaniae* (G.M.T.), the segments being deep in comparison with their length. The segments appear practically parallel-sided and do not differ greatly in size; the second, third, and fourth are longest and are sub-equal; the third attaining the greatest width; fifth, sixth, and seventh decrease slightly in length; the first (although comparatively long) is actually shorter than the seventh but is unusually deep—almost equalling the seventh in that dimension. On the sternite of the first peraeon segment is a large conical boss between the coxae of the gnathopods. The ventral borders of some of the segments have a few setae, the produced angles nearly always bear a spine and the fused coxae, too, carry a sparse ventral fringe. Sub-marginally, there are remnants of anterior and posterior segmental setal rows. Such a feeble development of setae is doubtless related to the burrowing mode of life.

Pleon. In the relative shallowness of the pleon pleura, *terricola* again shows a resemblance to *M. tasmaniae*; in the former, the greatest depth of pleon is not quite twice the depth of peraeon and is less than the width of that region, so that the body is really sub-depressed. Of *M. capensis*, Barnard notes that the width of the peraeon equals the greatest depth of the pleon, which is twice that of the peraeon. In *australis*, on the other hand, the depth of the pleon may exceed once and a half the greatest width of the peraeon. This comparative shallowness of the pleon region in *Phreatoicopsis* may be considered as either the retention of a primitive condition, or, alternatively, the result of reduction of the pleura as part of the general modification of the body to a more vermiform shape in relation to the burrowing mode of life.[1] If this latter explanation be accepted for *Phreatoicopsis*, it would seem that it should be extended to *tasmaniae*, also, and we should be compelled to assume that this species, too, had had, in the course of its evolution, a burrowing phase. Since the extreme spininess of *tasmaniae* is

[1] In certain distinctly subterranean forms (*Phreatoicoides*, *Hypsimetopus*, and *Phreatoicus*) there has been a very evident tendency for the body to become sub-cylindrical (almost semi-cylindrical), the pleura nearly or quite obsolete.

opposed to that interpretation, the explanation for the occurrence of such proportions in such widely separated species as *capensis*, *terricola*, *tasmaniae*, and *kirkii* would seem to be that it is a very primitive characteristic, older even than *wianamattensis*. Depth in these pleon pleura is usually found associated with the actively swimming habit, and it seems probable that it may serve to enhance the effect of the sweeping stroke of the pleopods. Chilton (1891, p. 154) has suggested that the pleura serve merely to protect these appendages, but it should be noted that in practically all Phreatoicids the ends of the pleopods are freely exposed below the pleura, whatever the depth of the latter, and that the exposure is greatest in forms of subterranean habit where protection of the pleopods from abrasion would seem to be most needed. The inferior margins of the pleura are set with a fringe of setae, which is continued up the posterior border. In this latter region, the fringe is actually sub-marginal but the setae mostly stand erect and thus are readily overlooked.

The *tailpiece* in side view (fig. 27, *3s*) appears as a truncated cone; the convex dorsal surface dips to a very slight concavity, behind which the actual posterior border rises in a scarcely elevated edge. This terminal elevation probably represents the telsonic projection of other genera; it is bent into a nearly circular piece (incomplete below) instead of persisting merely as a curved dorsal prominence. In the juvenile, there appears dorsally a distinct upturned part of this rim. The anal opening is a *vertical* slit guarded laterally by lips which fill the circular space included by the posterior border; these anal folds remain separate to the sternal level, an anterior part of the anal opening being continued on the sternal surface (fig. 27, *3v*). The ventral edge of this hinder telsonic region lies in the plane of the sternal surface, there being in this species no recognizable telsonic pleural extensions. More anteriorly, there is a slight development of the pleura, but it is negligible as compared with that found in other surface-living Phreatoicids, and comes very near to the condition observed in blind and wholly subterranean genera. The free telsonic edge (including the posterior margin) is fringed with short setae, interspersed with occasional larger spiniform setae. Immediately anterior to the uropod, the ventral margin bears a powerful spine, forward of which, as it bends upward to pass into the nearly vertical anterior border of the piece, are five or six evenly-spaced stout and curved spiniform setae with which may be mingled a few finer setae. Separating obliquely the ventral from the posterior margin is the curved articulation of the uropod, from the dorsal (posterior) border of which the suture of sixth pleon segment to telson appears as the usual well-defined ridge which, in this species, is free from setae or spines. Examined by reflected light, the whole surface shows a regular granulation which suggests an armour of closely-fitting scales, and which, in profile, is seen as a serrated edge.

The *antennule* (fig. 27, *4*) is stout, with distinct peduncle and a flagellum with from nine to twelve joints; these are cylindrical, mostly short and appearing almost square in outline. The appendage extends to about the middle of the fourth joint of the antenna and is sub-equal in length to its flagellum; olfactory cylinders are confined to the terminal four articles. The *antenna* is relatively short, barely one-third the length of the body, and its peduncle attains to a quite unusual robustness and actually exceeds considerably the length of its flagellum (as 5 : 4); the joints of the peduncle are progressively longer and less stout, the fifth being slightly longer than first and second combined, definitely longer than the fourth, but shorter than the combined length of second and third. The flagellum has, in fully-grown specimens, from twenty-seven to thirty-seven joints and is almost moniliform along the greatest part of its length, but near its end the joints become

longer and more slender; they bear setae each with a single sub-apical cilium (cf. *Eophreatoicus*). The entire appendage is rather more than twice the length of the antennule.

The *upper lip* (fig. 27, *5*), which is based on a broad, moderately deep, asymmetrical epistome, is almost semi-circular, its ventral border being slightly flattened, almost emarginate and completely fringed with thick fur of inturned setae; on either side of this central region is a bushy fringe of setae extending round nearly to the epistome, in some specimens briefly interrupted at one or two points. The anterior face of the epistome is strongly convex, that of the upper lip rather flatter; under a high magnification, its outer surface appears scaly.

The relations of the *mandible* to adjacent structures is more readily to be made out in this than in other smaller species. Its actual articulation with the head laterally is along a nearly horizontal line forming a hinge occupying rather more than the middle third of the ventro-lateral border. In this part, the mandible is very thick, its dorso-mesial surface occupied by the relatively huge adductor muscle; further attachment for the muscle is provided by a strong apodeme, which rises from just within the ventral border of the opening and spreads fanwise in the head. At its narrow (mandibular) end, this apodeme is dark and heavily chitinised and seems to be actually articulated by a strong hinge joint (fig. 28, *6r*). The anterior border of the opening for the muscle lies just against the hinder border of the base of the molar. The adductor muscle thus has its insertion within the mandible quite close to the origin of the molar. Both in front of and behind the mandibular articulation, the mandible is free but extends in contact with the head, a contact so close that it might appear to form part of the articulation. In front there projects the fulcral process, a large rounded boss which fits into a corresponding hollow provided in part by the labrum and in part by the ventral surface of the sub-ocular region of the head. Behind its articulation the hinder part of the mandible is greatly narrowed, this part of the edge resting against the anterior margin of the post-mandibular area. Here, too, is a large irregular 'ball and socket' articulation, but in this case it is the head, in the post-mandibular region, which projects and the hinder face of the mandible which is excavated into a distinct concavity. The postero-lateral edge of the mandible conceals the outer part of the maxillula; in *terricola*, this edge appears to be always uncovered, the epipodite of the maxilliped being narrow and its movement limited by the slot upon the gena.

The left mandible (fig. 28, *6l*) has three very strong teeth on its principal cutting edge, the most ventral being particularly large, the proximal sometimes indistinctly subdivided into two; the lacinia mobilis, also with three dark-coloured, heavily chitinised teeth, lies quite obliquely, mesial to the main dentate edge. The molar is very stout and comparatively short, its sub-circular grinding face concave. On the right mandible, the outer edge shows four teeth, the lacinia mobilis is much less strongly chitinised and has but two (sometimes three) teeth; the molar is long, relatively slender with its end obliquely truncated to present a downwardly, directed grinding face. In both, the palps are stout, the first and second joints sub-cylindrical, the third conical and curved; the first has a small series of spiniform setae distally, the second joint with some constituting an external fringe and a few others scattered on the mesial surface, the last joint with a rank of three or four strong, minutely denticulate spines and the whole of its inner surface covered with setules.

The lower lip (fig. 28, *7*) has a stout and fleshy basal region produced distally into an inner lobe scarcely distinct from the outer; it appears angular, the shape being liable to some alteration under pressure, and is set with an edging of fine

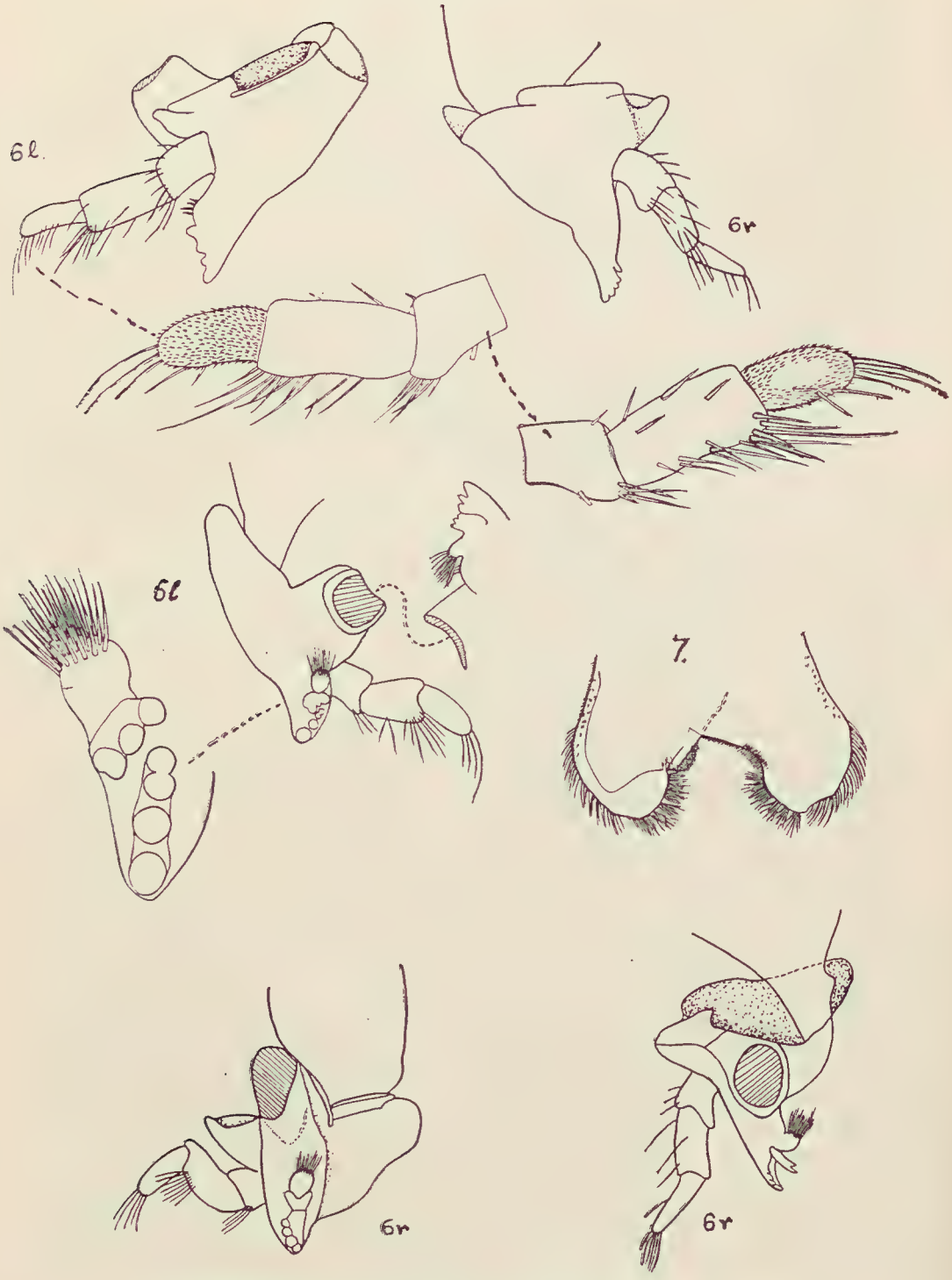

FIG. 28.—*Phreatoicopsis terricola* Spencer and Hall. Mandibles and paragnaths.

setae, but the outer is mesially incurved with dense fringing brush of setae. In this species, better than in most, can the character of this marginal fringe be made out as composed of stiff setae intermingled with close-set penicillae or setospines, about eight (perhaps more) in number. These penicillae appear to differ from the setospines which arm the inner endite of the maxillula chiefly in their shortness and greater bushiness. Upon the outer border of the lip is well developed a latero-distal fringe which fades away proximally into an imbricating (scale-like) edging of short setae.

In the *maxillula*, the structure described for *tasmaniae* by Sheppard from preparations cleared with caustic potash, can be made out quite readily in *terricola* if the appendages be examined by reflected light—the sutures and articulations being then plainly evident. It differs, however, from the account given of *tasmaniae* in that the third segment appears to be free. In the maxilla, some but not all of the parts may be distinguished in a similar manner. These appendages are, however, inadequately described by the statement that they 'bear a fairly close resemblance to *Phreatoicus australis*' (Sheppard, 1927, p. 118).

The maxillula (fig. 27, *8*) consists of the two well-chitinized basal segments of which the outer proximal piece (identified as the second segment) is triangular in shape, and larger, relatively, than in other Phreatoicids. With its outer border, articuates the dark-coloured, heavily-chitinized outer lobe, clearly divisible into two regions—a proximal, pyramidal in shape with its whole mesial surface occupied by muscle masses and its outer edge setose—and a distal sub-quadrangular piece. This latter has a nearly straight outer border for about two-thirds of its length and is then bent mesially, the setae decreasing in length and fading out beyond its mid-length; the inner border sinuous and clothed with setae. Distally, it is obliquely truncated and ends apically in a curved, sub-triangular surface. At the wider, lateral, end of this surface, there is a row of four dark, heavily chitinized spines or teeth, followed by five curved rows of three apiece with a single mesial tooth at the inner apex of the triangular surface. The regularity of the third row (counting from the outer end) is broken by the presence of an additional tooth. Thus, there are twenty of these spines, but there is probably some variation, since Spencer and Hall describe it as having a triple row of spines and a total of twenty-five. The short rank of plumose setae on the surface of the lamella, in other Phreatoicids, is here represented by two stiff pectinate setae or, in some, by one stout and two more slender setae. The inner endite, shorter and barely half the width of the outer, is a much less robust structure with convex outer and concave inner border, both setose. The free (distal) end is evenly rounded and armed with a close rank of long, slender setospines, about eight in number, and a second row of seven setae, shorter and pectinate. At its proximal end, the broadening anterior and posterior surfaces of the lobe become widely separated mesially, and into the large hollow so bounded, great muscles enter to have their insertion. Still more proximally, the lobe is continued as a narrow wavy chitinous band inserted on the distal aspect of the first segment of the appendage.

The figure of the *maxilla* given by Spencer and Hall (1896, pl. 4, fig. 6) requires some modification. The appendage (fig. 27, *9*) is set very obliquely to the transverse plane, so that the proximal endite is forwardly directed, the two plates of the distal endite lying one behind the other nearly as much posteriorly as laterally. In several features (relative proportions of lobes, disposition of setae, etc.) it seems to retain a primitive condition. Thus the three endites are approximately of the same length, and the inner endite has a relatively wide inner, concave, and sub-triangular surface presented antero-mesially. Its anterior sub-marginal fringe of setae, which may be either simple or pectinate, passes distally into a scattered

group which spreads to the outer edge of the apical tuft. The postero-mesial border has a dense fringe of long filtratory setae (fifty or sixty in number), set in a close comb-like row, extending from the proximal to the distal end where it passes into the apical tuft which arms the evenly-rounded apex. Immediately sub-marginal (posterior) to this comb is a third rank of setae, stiff, pectinate at their ends, more widely spaced and set at a different angle to those of the filtratory series. The series evidently forms a kind of protecting grill interposed between the filter setae in front and the brush setae of the maxilliped behind. This row, too, seems to merge into the apical cluster, which is dense and consists of mixed pectinate and simple setae with some partly plumose; one or two of the more lateral spines being stouter. The outer border of this proximal endite is fringed by a continuous line of setae. The two endites of the third segment are both strongly chitinised, are unusually long and narrow (cf. *typicus*), the inner being a little shorter than the outer, and bear on the rounded apices *two exceptionally stout* pectinate or denticulate spines surrounded by a number of typical slender setae. Both of these endites present an antero-mesial concave surface, and upon the outer of these are some finer, but equally long (or even longer), pectinate setae. The retention of such an armature of setae along much of the inner (mesial) aspect of this lobe is a feature, also, in *E. kershawi*, *P. typicus*, and *M. capensis*, though in these it is less strongly developed. In addition, the anterior surface of both inner and middle lobes is covered by a fur of setules, a condition almost peculiar to this genus.[1]

Between the bases of the maxillae lies a well-developed median process (fig. 2B).

Maxilliped. The condition of this appendage is shown in (fig. 27, *10*). It is extremely robust, the joints well rounded and relatively short; the coxa is large, basis wide and unusually short, merus, carpus, and propod strongly expanded, the latter rounded and expanded mesially. The epipodite, of somewhat irregular shape, springs from a wide base and has an almost complete fringe of very short setae and some scattered spinules around the outer border. The basis is produced into an exceptionally wide inner endite which extends forwardly between the proximal endites of the second maxillae. The mingled pectinate and brush setae which fringe the inner (dorsal) border of this plate form a continuous series in a double, or possibly a triple, row from its proximal end to its rounded apex; the setae, which are densely clustered apically are continued around to the posterior edge of the endite and extend also onto its outer (lateral) surface, where it is covered by the palp. Sub-marginally, these setae stretch along the ventral border of the endite, a number of them being modified into coupling setae. Four or five of these are very strongly curved, although apparently not provided with apical barbs or hooklets. The several joints of the maxilliped are armed distally with one or more incomplete bands of setae, while there is a fringe, also, along the median and lateral borders. In addition, stout setae are scattered plentifully over the ventral (morphologically, the posterior) surface of the several joints, a condition not observed in other genera. In the one spent female dissected, the coxal lobe projects almost directly posteriorly (i.e., at right angles to the hinder surface of the coxa of the maxilliped) as a narrow crescentic piece, its free convex border set with a fringe of long setae, the lobe itself appearing stiff and immobile. The brood-pouch which follows is made up of tough chitinous flaps, not very greatly expanded, those on second, third, and fourth peraeopods, all more or less alike; the first and second plates on the left overlapped externally the opposed pieces, while in the third and fourth oostegites the arrangement was reversed.

(1) Elsewhere seen in *S. ambiguus* and *U. pearsoni*.

On the gnathopod, the oostegite is very unequally bilobed, the larger posterior piece forming the anterior wall of the brood-pouch, the quite small anterior portion being bent in a plane practically at right angles to the hinder lobe and forms a concave, almost sheath-like, structure underlying the basal portion of the maxilliped. Between these, of opposite sides, project obliquely backwardly these oostegal (coxal) outgrowths of the maxillipeds.

Peraeopods. Sheppard states that in the female the coxal joints of second, third, and fourth peraeopods are free, a statement doubtfully confirmed by the examination of two large specimens. Of this anterior group, the peraeopods resemble those of *capensis* and of certain Tasmanian (*tasmaniae, brevicaudatus,* etc.) and New Zealand species *(kirkii)* in the rounded (cylindrical) condition of the joints; the basis of the hinder three pairs shows a little expansion. If the rounded condition be primitive, it must be of very great antiquity, for the Triassic fossil species *wianamattensis* had already acquired a very notable expansion of almost all of the joints of the peraeopoda. If, on the other hand, the rounded condition has come about by the loss of the plate-like portions consequent upon the adoption of the burrowing habit, it is obvious that it might have been attained independently in *Phreatoicopsis* and the several subterranean forms found elsewhere upon the mainland of Australia, in Tasmania and New Zealand. That would not explain, however, the occurrence of this condition found in certain of the Great Lake species; unless we are to suppose their present habit to be a reversion to a free-living condition which has followed upon a not too prolonged burrowing stage. *P. terricola* differs from *tasmaniae,* however, in the relative shortness of its peraeopods in the hinder series, in which particular it comes nearer to *M. capensis,* to which species, indeed, it bears many other resemblances. The longer legs of *P. tasmaniae* may be related to a more active running habit, for it may be found freely in hollows under stones, logs, etc., whereas most surface-living species live more or less buried in mud beneath liverwort or moss. The peraeopods are practically without setae or spines on the anterior border, but sparse spines fringe the posterior edge of the joints. In the hinder group of peraeopods a few spines occur on the anterior border also.

Pleopods. In the exopodite of the first pleopod, *terricola* has not departed greatly from that which is considered as the primitive shape—a long, sub-oval lamella, such as is seen in *M. capensis, M. tasmaniae, E. kershawi,* and *A. lintoni,* fringed in all of these forms with setae along the outer border and the distal half of the mesial border. But, whereas in *capensis* and *kershawi,* the endopodite has a similar shape and size (also, presumably, the primitive condition), in *M. tasmaniae* and *lintoni* the endopodite has dwindled somewhat, though retaining its narrow, sub-acute shape, in *terricola* it is markedly shortened. (It is of interest that in *Phreatomerus latipes,* although the pleopod lamellae are alike and equal, they have, as a series, become short and broad, presumably in conformation to the sub-depressed broadened condition of the body.) The sympodite is stout, dark-coloured, and heavily chitinized and is divided by a deep groove into two regions; from the distal spring the two lamellae and two lobes—one mesial (the coupling lobe), sub-triangular with apex directed distally and surmounted by three or four simple setae—the outer, possibly a vestigial epipodite, almost semi-circular, with crenate edge set with from ten or eleven long, simple setae. Lying posterior to this (i.e., in a position which such a lobe has normally to an epipodite) is a proximo-lateral extension of the exopodite which is developed in other Phreatoicids only on second and succeeding pleopods. More proximally, is the vestige of an inner joint, indicated laterally by a small swelling crowned with three or four stiff, pectinate setae.

In the female, the second differs from the first chiefly in being slightly longer and broader and in that the exopodite is two-jointed, its distal joint being, in shape a narrow oval. The endopodite is longer than that of the first pleopod and tends to be tri-lobed, perhaps the result of an incomplete separation of a wider basal and a narrower distal piece, in this resembling the shape of the endopodite of the first pleopod in the male. The sympodite differs little, the coupling lobe is rather longer and its apical portion somewhat bent and the vestiges of an epipodite rather larger.

In the male (fig. 27, *13(2)* ♂), the second pleopod shows the modified endopodite clearly marked into two regions—a proximal, broad, sub-triangular or nearly semi-circular, from its distal edge springing the respiratory lamella laterally and the penial stylet mesially; the latter is quite stout, curved, not noticeably tapering, and longer that its related lobe and ends in a pointed apex devoid of long spines or setae—thus being intermediate between the Amphisopine and the Phreatoicine condition. Its apical region, however, may be set with a number of short spinules, and in one specimen, on one side only, was found a short rank of stiff setae.

The third, fourth, and fifth are alike in both sexes and differ little in size from the second, but the epipodites which are borne on a short stalk are progressively smaller and change in shape from reniform to oval and to round.

The *uropod* (fig. 27, *3s*) is stout; its peduncle short and broad, concave dorsally. The inner edge is well raised and is spinose, having seven or eight strong spines, the last two, mounted on a well-developed distal process, stronger than the rest (cf. *pearsoni*). The outer, and much lower, edge is furnished with but three stout spines. The ventral border of the peduncle is armed with an anterior spinule followed by three spines each accompanied by a setule; the single terminal spine beneath the insertion of the outer ramus is strong and entirely free from teeth or pectinations. It may be flanked by a second more slender simple spine. Of the rami, which are strongly curved, the inner is much the longer and greater in length than the peduncle; both are stout, produced into a long sharply-pointed end, the inner armed laterally with one or two spines and a few scattered setules.

Colour. The animal in life is translucent with pale bluish-white tint, the intestine showing through as a dark shadow; cadium yellow markings always present on head and variably on sixth and seventh peraeon segments and first, third, and fourth pleon segments. When present on the body, the yellow colour appears in narrow transverse bands, generally near the hind border of the segment; in most specimens, these bands were restricted to the hindmost two segments of the peraeon. In spirit material, the colour fades to a dull creamy white.

Size. Spencer and Hall record this as 45 mm. Two or three specimens have been taken which in life slightly exceeded this.

Occurrence. Otway Mts., on hills overlooking the Gellibrand R. (Spencer and Hall). Mt. William (near Ararat) and the Grampians (Raff), but as suggested below, the specimen from the latter locality should perhaps be assigned to a new species.

Of the specimens attributed to this species, there have been examined (in 1928) all which were then in the collections of the Museums of Melbourne and Adelaide obtained from the Otway Ranges and also from the Grampians. In addition, a couple of preserved specimens were given by Mr. Searle of Melbourne and a quantity of living material collected by Professor Wadham of the University of Melbourne, to whom the writer desires to take this opportunity of expressing very sincere gratitude. Of a total of twenty-eight large specimens examined, thirteen were males and, of these, three showed tough, or calcified, and spatulate

incipient brood lamellae closely adpressed to the sternite, while in another three the lamellae were present but more weakly developed. Fifteen were undoubtedly females, but no fewer than five had penes well developed. These must develop quite early, for they were evident in one small male specimen, in which the penial stylet, although indicated, had not become distinct from the endopodite of the second pleopod.

Since the gnathopod is alike in both sexes and there is no sexual modification of the fourth peraeopod, the determination of the sex in such cases can be made only by examination of both the seventh peraeopod and second pleopod.

In at least six partly-grown examples showing the first stage of the brood lamella, the pleopods were of the male type and particularly long penes were found arising from the coxa of the last peraeopods. On large spent female, with fully-developed brood-pouch, however, showed penes present on segment seven, although the second pleopod was without penial stylet. Subsequently, four others, both mature and immature females, were found with moderately-developed penes. These apparently differ slightly in shape from those seen in the male, being rather shorter and more flattened.

One female of 39 mm. was ovigerous, the brood-pouch containing about thirty embryos with some Temnocephala! A second female (30 mm.) exhibited a well-developed external hermaphrodite condition. In this specimen, the oviduct opened at the median end of a long ridge which seemed to be a mesial extension of the coxa.

It was noted of *Eophreatoicus* and of *Amphisopus* that in the male there is a development upon the maxilliped comparable to, but smaller than, the normal oostegal flap on that appendage in ovigerous females.

Of the specimens taken in and near the Grampian Mountains, none examined seemed mature. In several features there appeared differences from the condition recorded for *terricola*, but the material was too scanty to warrant the institution of a new species.

Uramphisopus, gen. n.

Body robust, sub-cylindrical, fusiform. Head relatively long with short and wide sub-ocular incisure, cervical groove partly concealed by coxa of gnathopod, and with small posterior process; eyes comparatively small but prominent, apparently undergoing reduction; both head and peraeon wider than deep, anterior three peraeon segments notably shallow, pleon appearing compressed, the full depth being once-and-a-half as great as the width in that region; tailpiece comparatively short, apex short and wide, abruptly upturned.

Antennule relatively long, but flagellum with few joints; antenna of moderate length; lacinia mobilis of right mandible small, united with spine row; maxillula with few (four) setospines on inner endite, maxilla with endites of third segment short; gnathopod strong; bases of hinder peraeopods only moderately expanded; pleopods with stiff setae on anterior face of exopodite, penial stylet long, armed terminally with spines; uropod with huge mesial process which can be apposed to its fellow of the opposite side, and then completely closing the telsonic arch; the apical spine beneath insertion of rami, stout and notched, rami without terminal movable spines.

Genotype. *Uramphisopus pearsoni*, sp. n.

The relative proportions of peduncle and flagellum of the antennule found in this genus are quite unusual. The eye is small with few but unusually large

ocelli—its condition suggests approaching obsolescence. The occurrence of abundant setae on the face of the exopodite lamella is a feature occurring in several Amphisopine genera—outside of which it is practically restricted to *brevicaudatus*. The telsonic apex is strikingly like that of *brevicaudatus*; it differs from that species, however, in the retention of a small lacinia mobilis on the right mandible; the condition of the endites of the maxilla comes nearest to that found in *Phreatoicopsis* and *Synamphisopus*, in which genera, also, there is a large mesial process upon the uropod—but in *Uramphisopus* this latter reaches its maximum development. Since a much smaller but quite distinct process is also found in *Hyperoedesipus* and *Phreatoicoides*, it is possible that it represents a device of value to burrowing forms; but the condition in the two last-named genera suggests a retrogression in the structure which may be due to the partial abandonment of the burrowing habit for life in underground waters.

Uramphisopus pearsoni, sp. n.

(Figs 29, 30)

Male. *Body* robust, sub-cylindrical; in dorsal view, fusiform, having a nearly uniform width from second to seventh peraeon segments (male) and tapering both to head and tail; its length six times its greatest width; not sculptured nor ridged, spines absent, setae scanty but occurring rather more abundantly in the pleon where they become longer and finer.

The *head*, which is as long as the combined length of first and second peraeon segments, measured in mid-dorsal line, is free from the first peraeon segment; it is wide through its whole length, and deep; its anterior border only shallowly emarginate; eye, of moderate size but scarcely prominent, and apparently by way of becoming obsolete, there being only about fourteen or fifteen rather large ocelli, laterally placed, in some specimens without pigment;[1] the distance between eyes about six times their long diameter, this inter-ocular surface being scarcely concave. The sub-ocular incisure is well marked but very shallow, gaping widely, its ventral margin extended as the long upper edge of a distinct sub-ocular or antero-lateral lobe of the head. The hollow behind the eye is shallow, the genal groove short. The ventro-lateral border of the head runs slightly above the mandibular articulation and dips down into the post-mandibular region so that there is only a small ventro-lateral (maxilliped) area below. The pre-mandibular part of this border is short, the mandibular articulation long, the post-mandibular area short and deep, overhung by the coxa of the gnathopod and produced forwardly into a very small 'posterior process'. The cervical groove rises from the ventral border but, at its lower end, is hidden by the overhanging coxa. It is separated only by a ridge from the intersegmental groove which marks off the first peraeon segment from the head. Higher up, on the side of the head, the groove deepens but does not meet its fellow dorsally, so that in this species (unlike *brevicaudatus*) the maxilliped segment is not quite completely marked off from the head.

First peraeon segment very short dorsally, expanding somewhat below where it is much wider than the coxa of the gnathopod, its hinder angle rounded. In dorsal view it is seen to embrace the side of the head in a fashion reminiscent of *Phreatomerus latipes*, but differing markedly from that species in that this segment is not fused with the head. Transversely across the sternite is a stout ridge,

[1] It is, of course, possible that this appearance is due to post mortem change, and marks an early stage in the maceration of these specimens in the stomach of the trout; it seems, however, to be a normal condition.

against which the coxae of the maxillipeds rest. In the first, as in all the succeeding peraeon segments, the postero-lateral angle is fringed with setae. In the second to the seventh peraeon segments, the antero-lateral angle, also, is produced downwards in front of the related coxa and is, similarly, seta-fringed but in the first peraeon segment such a free anterior lobe is absent and the coxa, of unusually large size, appears firmly fixed to the segment. The second, third, and fourth segments are sub-equal and longer than the fifth to seventh (which also are sub-equal), but the second and third are distinctly shallower than the others. The coxae of the first to fourth peraeopods appear completely fused with related segments, but in the fifth to seventh they are clearly defined and may be free.

The *pleon* segments short, the first shortest, the first and second together about as long as seventh peraeon segment; the third and fourth increasing slightly in length; the fifth not very long but still about equal to third and fourth combined; the tailpiece, including telsonic projection, is scarcely longer than the fifth. The pleura of first pleon segment shallow, scarcely extending below the level of the seventh peraeon segment; the second to fourth expanding ventrally, so that they are longer than their segments; that of the fifth is much longer, meeting the tergum behind in a rounded notch. They are all bordered ventrally by long, slender setae, this fringe in the second to fifth segments being continued upward along the posterior margin of the pleura. The tailpiece, in profile, shows a nearly straight dorsal line, separated by a sharp notch from the terminal telsonic projection which is abruptly upturned; this is, in this species, very short and wide, narrowing apically, its hinder end is continued downward into a flattened posterior surface (fig. 29, *3v*), the ventral border of which forms the upper boundary of a narrow arch, of which the sides are formed by the telsonic pleura. These, seen in side view, are almost straight and bear numerous (eight to ten) spines, one or two of which are slightly stronger than the others; immediately sub-marginal to the fourth is another slender spine. The vault of this arched end of the body lies practically at the level of the sternite, so that the anal opening is not terminal as in *terricola*, but postero-ventral, but in any case it is normally hidden by the huge paired mesial processes of the uropods which can be apposed in such a way as practically to close this telsonic arch behind. Ventrad to the telsonic pleuron, the margin is occupied for a considerable stretch by the insertion of the uropod, the peduncle of which is unusually broad; from the upper end of the insertion a sutural ridge extends antero-dorsally halfway across the tailpiece. The ridge is armed by a dozen long, stiff spine-setae. The pleuron of the sixth pleon segment immediately anterior to the lower end of the insertion of the uropod is convex and bears numerous (about a dozen) long, stiffly-curved setae, almost all of which are apically toothed. The series ends in one immense spine, with three of four slender flanking setae; the condition of this region being strikingly like that of *ambiguus*. Dorsal to this row of setae, the pleuron is excavate, producing a distinctly *concave* anterior border. The dorsal edge of the telsonic apex is armed with one pair of spines and a close tuft of probably a dozen very long setae between.

Appendages. In the mature male, the *antennule* (fig. 29, *4*) presents a condition not found in any other Phreatoicid. It is relatively long, as compared with the antenna (in this agreeing with *Amphisopus*, *Phreatomerus*, etc.), reaching in its natural position practically to the end of the peduncle of that appendage, but of its length, its peduncle contributes three-fifths, stretching nearly to the end of the fourth joint of peduncle of the antenna. Moreover, the three joints of the peduncle are sub-equal—the second joint slightly the shortest. The first joint is clothed with short, fine setae and appears unusually wide, this being due to its production into a lateral keel. In immature specimens the antennule may fall a

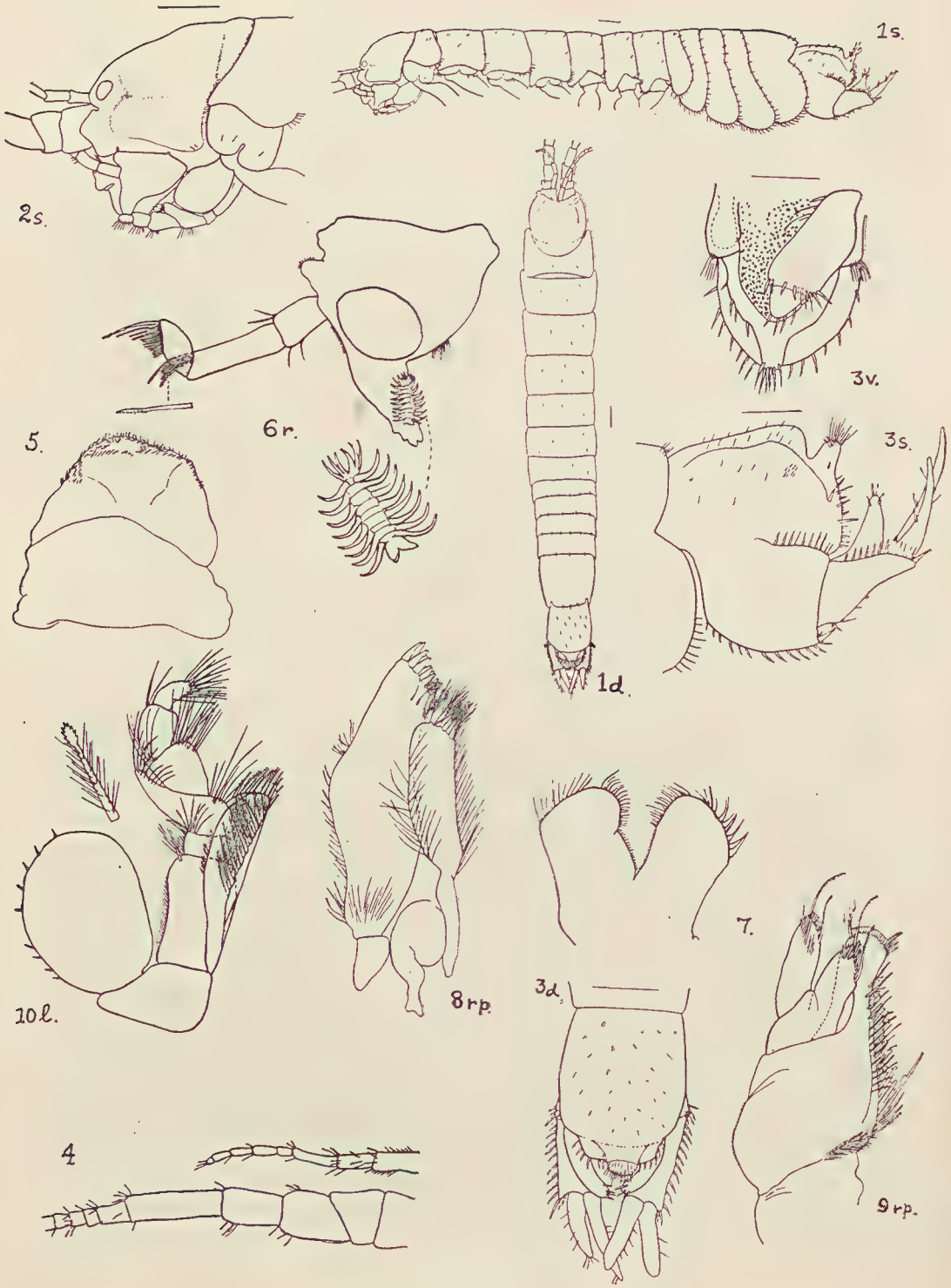

FIG. 29.—*Uramphisopus pearsoni*, sp. n.

little short of the length of the antennary peduncle. The *antenna* is of but moderate length, being scarcely as long as head and first four peraeon segments; its peduncle stout—the first and second joints sub-equal, third joint as long as fourth, fifth joint barely three-fourths of combined length of third and fourth; flagellum with twenty-two joints (male) once-and-a-half the length of peduncle; the first joint of the flagellum, although relatively short (only one-third of the length of the fifth joint of peduncle), is, nevertheless, *much* longer than any subsequent joint.

The *epistome* is strongly projecting and overhangs the *labrum* (fig. 29, *5*), which is markedly asymmetrical; it is roughly semi-circular in outline, but a strong sub-median ridge lies all askew. The *mandibles* are particularly massive, with powerful molars; the short, stout palp has the first joint with few setae, a little longer than the third, the second, with a small apical tuft of setae, almost twice the length of terminal joint, which bears a row of pectinate setae along one-half its length. The left mandible has a cutting edge with four strongly chitinized teeth and a short, wide lacinia mobilis, also, with four teeth; on the right appendage the primary cutting edge has four teeth and its spine row is attached unusually far distally; the lacinia (fig. 29, *6r*) is no longer distinct, but is a small bi-dentate structure united with the distal (outer) end of the spine row, its teeth minutely denticulate. Posterior to the base of each molar lies a curved row of setae. The fulcral process is pronounced and apparently setose.

The *lower lip* shows practically no differentiated inner lobes, while the outer gape widely and appear angular rather than rounded with sparse fringing setae.

Maxillula. The outer (distal) endite (fig. 29, *8rp*) is strong and presents a somewhat unusual shape, being bent and norrowing sharply to its apex. It is armed with ten to twelve simple spine-teeth in two rows with a single short seto-spine, just external to the innermost tooth. On the same (posterior) face of the lamella are two long plumose setae, rising near to the mesial edge. On the inner endite, which may widen slightly to its apex, are four stout setospines with two slender spines (simple or feebly-plumed) corresponding in position with the two simple setae of Chilton's description of *australis* (1891, p. 158, pl. 23, fig. 7). The outer margins of both endites and the entire mesial border of the inner endite are fringed with fine setae.

The *maxilla* (fig. 29, *9rp.*) is notable for the relatively great development of the proximal endite. It extends as far distally as the outer of the two distal endites; both of these are small and short, the inner of the two particularly so, recalling the condition found in *Phreatoicopsis* and *Synamphisopus*. The outer-most rises from an especially pronounced pedicel and gives to the appendage an appearance strikingly like that of *Apseudes* (in which genus the outer member is interpreted as a palp). Upon the proximal endite, the antero-mesial edge bears a close-set row of filter setae, supported by the usual posterior sub-marginal row of finely-pectinate setae. Both ranks end a little short of the apex which is rounded and bears a single row of spines, coarsely denticulate mesially but becoming feebly plumose laterally. Both of the distal endites are obliquely truncated and bear a short rank of more or less finely-denticulate spines; sub-marginally on the posterior face is a rank, variable in its length of simple setae.

Maxilliped (fig. 29, *10l*). The coxa is large and backed posteriorly by a strong transverse ridge on the sternite of first peraeon segment; the basis is very stout and of moderate length, with the usual single plumose seta at its outer distal angle; its endite is fringed with about ten plumose setae. These are restricted to the distal half of the mesial edge and each has a very stout base; the distal four are peculiar, being flattened apically in a manner which has been observed

in no other Phreatoicid. The endite itself appears unusually long, perhaps due to the fact that the palp, though stout, is relatively short. The epipodite has a sparse fringe of spinules laterally, and extends distally just beyond the basis.

The *gnathopod* (fig. 30, *11*) is very short and stout, the basis almost without setae, except for a proximal tuft on the anterior border which is, however, not always present; the ischium is relatively short, the merus strongly produced anteriorly, its free end fringed with long setae; the hand is very strong, the greatest length of the propod actually exceeding that of the basis and its width is sub-equal to the length of that joint; the anterior border of the propod is strongly convex, the posterior much shorter, about two-thirds only of the length of the palm which is nearly straight and bears an uneven rank of short strong spines, each dentate on its posterior edge; the dactyl, nearly as long as the basis, is little curved, its palmar border fitting closely against these spines.

Peraeopods. The second and third peraeopods are alike, except that the basis of the second has, in addition to its proximal tuft of setae, a rank of short setules on its anterior border. In the succeeding limbs, the basis is fringed along both borders with longish flexible setae. The fourth (fig. 30, *12(4)*) is rather more obviously capable of gripping, but even in this appendage the spines on the propod are not noticeably long and strong, while those on the carpus are rather stouter; it is possible, therefore, that here, as in *Amphisopus*, the terminal *three* joints together function as a clasping hand. The fifth, sixth, and seventh (fig. 30, *12(7)*) peraeopods are, also, much alike, except for the increasing length of limb and degree of expansion of basis. In general, the joints are fringed with flexible setae, but on the distal joints of sixth and seventh, these may be partly replaced by stout spines. In the sixth the merus is somewhat produced distally.

Pleopods.[1] While these lack the large development of the sympodite of the first pleopod they, nevertheless, come near to the condition found in *brevicaudatus* in the occurrence of abundant stiff, simple setae on the anterior face of the exopodite, a condition found elsewhere in *Mesamphisopus*, *Amphisopus*, and *Paramphisopus*. In the first pleopod (fig. 30, *13(1)*), the sympodite is much shorter than in the corresponding appendage of *brevicaudatus*; its distal mesial angle produced into a definite lobe armed with nine or ten long, slender, doubly-pectinate setae. For the most part, these entangling setae are marginal, whereas in *brevicaudatus*, the marginal pectinate setae are fewer, but there are several tufts of stiff, simple, sub-marginal setae. The outer border of the sympodite in *pearsoni* is expanded and bears a fringe of short setae. The exopodite is long and lanceolate, the setae on the distal third of the outer border plumose, these continuing around the apex onto the distal end of the inner border, the rest of the setae on this border being finely pectinate. The sub-marginal fringe consists of long, simple, flexible setae. The endopodite is rather more than half as long as the exopodite and is greatly swollen, but in the specimens examined it is edged by a delicate membranous border. This appearance may be a consequence of incipient digestion in the stomach of the trout. In the second pleopod (fig. 30, *13(2)* ♂), the fringe of plumose setae is rather more extensive, the sub-marginal setae tend to spread well in onto the face of the lamella, *particularly on the proximo-lateral lobe.* There is a small proximo-mesial exopodite lobe almost devoid of setae. In the male, the penial stylet is long with a series of seven spines, of which four are terminal, diminishing in length and followed by three much shorter spines placed sub-terminally; the distal end bears numerous setules. The related endopodite is rather short and its basal region very robust, giving the sympodite an appearance

[1] This species being from the Great Lake (Tasmania) was originally compared in detail with *brevicaudatus*, with which it appeared to have much in common.

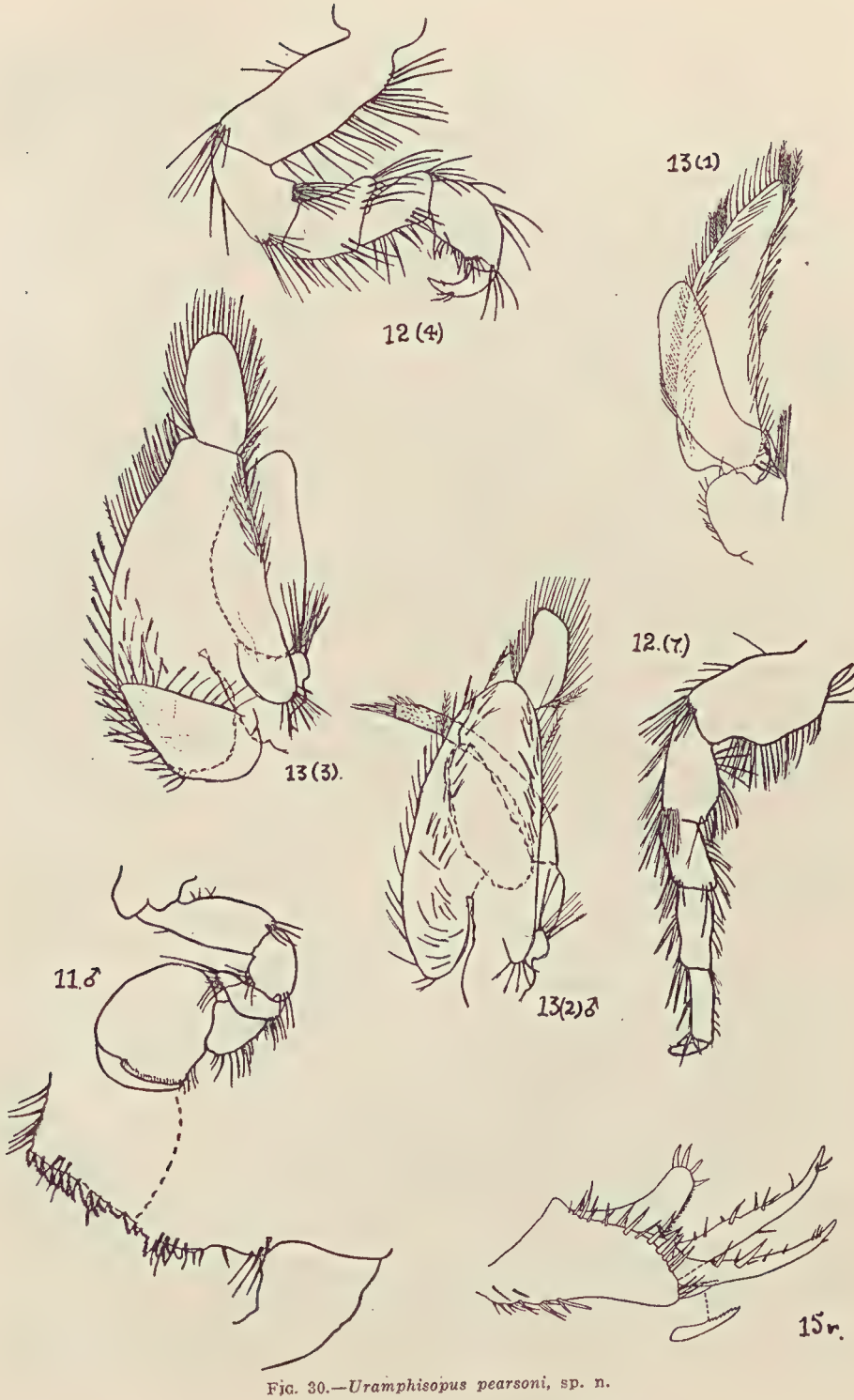

Fig. 30.—*Uramphisopus pearsoni*, sp. n.

of unusual length; the coupling lobe bearing pectinate entangling setae is pronounced, situate just proximal to the origin of the endopodite. In the third pleopod (fig. 30, *13(3)*), the endopodite is relatively longer, practically as long as the basal joint of the exopodite; this is, on both its lateral and mesial borders, greatly produced proximally; the lateral fringe of plumose setae is restricted to the distal half of the appendage; sub-marginal setae form a fringe on the distal half, only, of the inner border, but are abundant and scattered on the latero-proximal part of the joint, some of these being pectinate; entangling setae arise in two widely separated groups proximally and distally on the sympodite; the epipodite is large and sub-triangular, arising by a very narrow stalk, and is fringed with long, doubly-pectinate setae.

The *uropod* (fig. 30, *15*) is notable for the exceptional development of the mesial process. The peduncle is stout, very deep basally, its outer border tapering away distally. On the inner edge there is a great flattened process, rounded apically and armed with four stout spines; it is shorter but much stouter than the two rami and gives to the appendage a triradiate appearance seen in other Isopods, chiefly in the Cymothoidae. The two rami are sub-equal, slender, and tapering, armed with a few spines and setae. The ventral edge of the peduncle bears on its anterior half several tufts of mixed spines and setae; the distal half is unarmed, except at the apex, which bears one very strong spine dentate along half its dorsal border and flanked by three or four more slender, simple spines.

The *typhlosole* in this species is large, circular in section.

Colour. All of the specimens examined have been taken from the stomach of trout. They are almost invariably pale brown in colour, and all appear to be males.

Size. This is probably the most robust of the Tasmanian species; its maximum length is about 22 mm.

Occurrence. Probably a burrower in the floor of the Great Lake. Its colouring is uniform and agrees closely with that of the coating of mud found on many specimens; the eyes are evidently undergoing reduction. It appears rarely in collections (three stomachs only contained representatives of this species) and has never, apparently, been taken in any other manner.

The species is named in compliment to Dr. J. Pearson of the Tasmanian Museum.

The type is lodged in the Tasmanian Museum.

Sub-family V. HYPSIMETOPINAE

Body vermiform; head long with cervical groove, eyes wanting; antennule short, antenna long; first peraeon segment long, free from head; telson truncated. Gnathopod attached well behind head, differing in the two sexes; fourth peraeopod sexually modified; pleopods without coupling hooks; endopodites reduced and epipodites present or wanting; penial stylet short, strongly bent and unarmed apically; uropod having rami with fixed terminal spines.

Two genera with four species are placed together here and are doubtfully included in the Amphisopidae. All are specialized forms which lead a subterranean life, probably adopted at a very remote period. Their distribution somewhat parallels that of the Phreatoicopsinae, two species being found in Victoria from the Otways and Gippsland, the other two from West Tasmania—a very ancient geologic formation, probably at least as old as the Great Lake.

The elongation of the first peraeon segment is probably a consequence of life in underground crevices, which has led to the vermiform condition—the shortened pleon is probably another result of that mode of life. In the pleopods *Hypsimetopus*

retains on the *endopodite* of the first pair a few plumed setae, evidence of a one-time natatory function, as well as the usual complement of three pairs of epipodites. The *Phreatoicoides* species have lost epipodites as well as most or all of the plumed setae from the *exopodites*, the endopodites being wholly unarmed.

Hypsimetopus Sayce

Sayce, 1902, p. 219.

Body slender, sub-cylindrical; *head* longer than deep but shorter than the combined length of first and second peraeon segments, without eyes or sub-ocular incisure, with transverse groove; first *peraeon* segment free from head, first four peraeon segments sub-equal; *pleon* short, less than half the combined length of head and peraeon, pleura little developed, tailpiece longer than fifth pleon segment, narrow posteriorly and truncated, the end armed with two stout spines and a cluster of setae not appearing in lateral view.

Antennule short; antenna long; epistome forming a conspicuous transverse ridge; right mandible probably with reduced lacinia mobilis; inner endite of maxillula with six setospines and one simple spine; maxilliped with palp long, epipodite sub-pentagonal. Gnathopod of male with both basis and ischium short and broad, propod very stout; fourth peraeopod not sexually modified; hinder peraeopods with dactyl long; pleopods largely exposed, both exopodite and endopodite of first pleopod with plumose setae, second pleopod of male with penial stylet short, strongly curved, tapering and unarmed; epipodite on three hindmost pleopods, endopodite not markedly reduced; peduncle of uropod raised on its inner dorsal edge, rami shorter than peduncle apical spine fused with rami.

Genotype. *Hypsimetopus intrusor* Sayce.

Hypsimetopus intrusor Sayce

Sayce, 1902, p. 210, pls. 18, 19 *(Hyp. intrusor)*.
Sheppard, 1927, p. 121 *(Hyp. intrusor)*.

With the characters of the genus, to which the following may be added:

Body smooth and practically free from setae, except on the tailpiece. *Head*, eyes wanting, with a few setae on anterior border; first peraeon segment slightly produced antero-ventrally. Antennule not reaching end of fourth joint of peduncle of antenna, flagellum with seven joints, slightly swollen terminally. Antenna long, with more than thirty-three joints in the flagellum. Left mandible with four teeth on primary dentate edge, three on lacinia mobilis; on the right mandible between spine row and primary dentate edge (with four teeth) is a 'single stouter, simple spine' which can be nothing but a lacinia mobilis greatly reduced; setae on terminal joint of palps 'faintly feathered'. The maxilla is figured as having a small series of short setae (presumably filtratory) restricted, as in *Phreatoicoides*, to the proximal part of the inner endite; a gap separates these from an apical series of long setae. In the maxilliped, the brush setae are figured as passing to the apex of the endite. The gnathopod is massive and is unusual in that the dactyl is figured as distinctly shorter than the palm; both the basis and ischium are unusual in shape, being short, as wide as long. Peraeopods slender, basis scarcely expanded.

The pleuron of the fifth pleon segment is shown as fringed with setules, that of the sixth fringed with six simple spines of varying stoutness. Posterior to the insertion of the uropod, the telsonic pleuron bears one or two spines and several setae.

The suture between sixth segment and telson is indicated apparently by a very short and wholly unarmed ridge, but possibly there is present a line of spinules as in *Eophreatoicus*.

Size. Male 15·5 mm.

Colour. Creamy white in alcohol

Occurrence. Associated with *Engaeus cunicularius*, in burrows in the earthen dam of a mine 'near Zeehan, West Tasmania' (1901).

Three attempts have been made by the writer, and another by a student in the Department, to rediscover this species. All have been unsuccessful. The foregoing account has been based, therefore, on the account given by Sayce.

Phreatoicoides Sayce

Body linear, sub-cylindrical. Head long and shallow, produced well in advance of mandible, anterior border slightly emarginate, minute sub-ocular incisure, well-marked cervical groove near posterior margin, mouth parts forwardly placed, disclosing ventro-lateral part of head, posterior process not discernible; eyes wanting; terga of peraeon segments shallow, not concealing ventro-lateral part of segment; first peraeon segment long and free from head, produced very little forwardly onto the head, sternites produced into ventral median prominences, gnathopod with coxa small and set well back behind head; pleon very short and but slightly laterally compressed, pleura practically wanting, wholly exposing the pleopods which are without epipodites. Tailpiece large and truncate, wider than the rest of the body and attached by a narrow joint. Antennule almost filiform; antenna very long; right mandible with vestigial lacinia mobilis, maxillula with but three setospines on inner endite. Gnathopods of breeding male very large, the palm defined by prominent tooth; fourth peraeopod little sexually modified; uropod with short stout peduncle and styliform rami.

Genotype. *Phreatoicoides gracilis* Sayce.

Phreatoicoides gracilis Sayce

(Fig. 31)

Sayce, 1900, p. 122, pl. 10-12 *(Ph. gracilis)*.
Sheppard, 1927, p. 120 *(Ph. gracilis)*.

Sayce's figure suggests that the body is rather more setose than in either of the other two species, from both of which it differs, also, in the depth and shortness of head, the proportions of the first peraeon segment, the length of the seventh segment and in the proportions of pleon segments and tailpiece.

In this species, the head, as compared with peraeon, is not particularly deep, a sub-ocular incisure can be made out, there is a mere indication of a cervical groove, the first peraeon segment is the shortest, but, even so, is little shorter than the head, while both the second and third segments are distinctly longer than the head. In the male of both *longicollis* and *wadhami*, the first segment is longest and is more than twice the length of the seventh which, in Sayce's figure of *gracilis* (l.c., pl. 10) is shown as *longer than* the first. In the pleon, the fifth segment, too, is rather shorter, but the tailpiece relatively longer; the entire pleon (as compared with the cephalo-peraeon) attains its greatest degree of reduction in this species.

Of differences in the appendages, the following should be noted. Antennules and antennae are both rather more setose than in *longicollis*. The fringe of setae on the ventral border of the labrum is continuous. Of the mandibles, Sayce has stated (1900, p. 129) that they 'differ in no essential respect from *P. australis* and *P. terricola*'. Actually these two species differ widely in this appendage, *Phreatoicopsis terricola* showing a well-developed lacinia mobilis on the right mandible, whereas in *australis* and its congeners the structure has been wholly lost.

In all three species of *Phreatoicoides*, the right lacinia is present but greatly reduced. In *P. gracilis*, this structure appears as a slender two-pronged fork and lacks the inner denticulation seen in *longicollis*; in the palps the proportions of the joints, as recorded by Sayce, differ from those of *longicollis*; in the left mandible there are said to be four teeth on both cutting edges, in the Tasmanian species there are but three on the lacinia.

In the *maxillula*, the occurrence of three setospines on the apex of inner endite is apparently constant for the genus, but in *gracilis* the apex is much less oblique; the two simple spines sub-terminal to the setospines are variable; on the outer endite, Sayce records eight or nine spines in *gracilis*; in *longicollis* there are eleven or twelve.

So far as may be judged from Sayce's figure (1900, pl. 12, fig. 7), there is no important difference in the maxilla, although the gap found, in the proximal endite, between proximal and distal setae seems to be less evident in *gracilis*.

The *maxillipeds*, according to Sayce, 'are almost identical' with those of *australis*; they are apparently somewhat variable, for in the single specimen which has been available for examination the condition differs in setosity, etc., from that described by Sayce. It may be said to resemble that of *australis* only in so far as the maxillipeds of this sub-order are all superficially much alike. The coxa is not particularly short; the epipodite long, oval in shape and without fringing setae—the basis is about twice as long as wide; on the endite the long 'brush' setae fringing its dorsal edge are few in number and there is a gradual transition into the condition of the apical setae. On the dactyl there is a fringe of setae on the outer (lateral) border, almost as close as that upon the mesial.

The hand of the *gnathopod* in the male has been described by Sayce as occurring in two conditions 'normal' and 'hymeneal'. The normal condition is said to be similar to that of the female; the hymeneal Sayce found limited to males from 9 mm. to 12 mm. in length, the 'normal' condition occurring in larger specimens (up to 17 mm.). As specimens were said to reach 20 mm., it may be assumed that the largest specimens were female, although a female with brood-pouch is recorded as measuring 12 mm. It seems possible that there is here a protandrous hermaphroditism and that the larger specimens were undergoing a sex change. In the one specimen (male, 10 mm.) examined (fig. 31, *11*) the condition of the hand is apparently intermediate between the hymeneal and the normal. There is some variation, also, in details of setation, shape, and proportion of joints. In *P. longicollis*, the propod is much stouter relatively, although the species does not attain to so considerable a size and the shape of the joint is reminiscent of that of *Phreatoicopsis terricola*; a likeness which is still more evident in *P. wadhami*.

Peraeopods. The fourth peraeopod (fig. 31, *12(4)*) is not sub-chelate and the dactyl is very short, but the development of the spines, etc., suggests that the terminal three joints may be capable of a slight prehensility. Sayce's figure (l.c., pl. 12, fig. 11) of the third peraeopod gives the same impression. The seventh

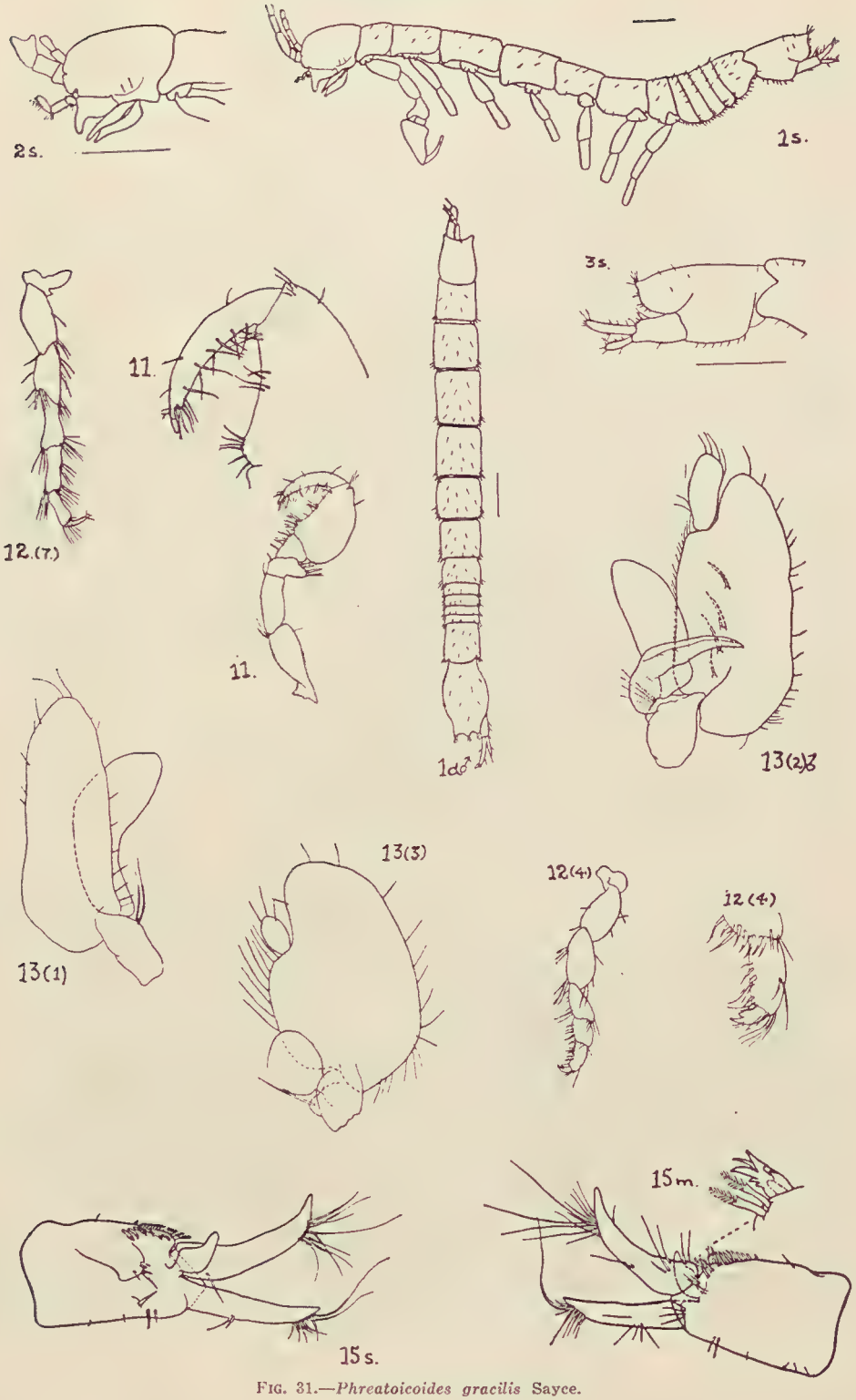

FIG. 31.—*Phreatoicoides gracilis* Sayce.

peraeopod (fig. 31, *12(7)*) is distinctly longer than those preceding; the joints from basis to propod show a slight progressive increase in length; the dactyl is relatively long.

The *pleopods.* In the first (fig. 31, *13(1)*) of the series, the lamellae are long, oval in shape, the endopodite not greatly reduced, the exopodite with a sparse fringe of simple setae in its distal half. The sympodite is long and bears several long entangling setae. In the hinder appendages there is a marked decrease in the size of the endopodite as well as in the distal lobe of the exopodite. Scattered fringing setae may occur around the whole border of that lamella, but even the second, in the specimen examined, is much less setose than that figured by Sayce (l.c., pl. 12, fig. 13). It is of interest that, in the second pleopod (fig. 31, *13(2)*) of this 10 mm. male specimen, the penial stylet is more strongly developed than in the large male (17 mm.) figured by Sayce, which may perhaps lend support to the suggestion that the species may be hermaphrodite and protandrous, the stylet undergoing reduction in size in later ecdyses, that is, with increasing age. It is in this specimen that the marked likeness of this penial stylet to that of *P. terricola* and *H. intrusor* is so noticeable; it is definitely of the Amphisopine type rather than the Phreatoicine. In all of the pleopods, the lamellae may be greatly narrowed proximally to appear stalked—a condition that occurs variably developed in many subterranean forms.

Uropods (fig. 31, *15*). The peduncle is short and stout, and comparatively bare of setae. Neither inner nor outer dorsal borders are raised, but distally, near to the middle of the dorsal surface, the peduncle is produced into a well-marked spine, as in both of the other species of *Phreatoicoides.* Rather surprisingly, this does not appear in Sayce's figure (l.c., pl. 12, fig. 14), nor is it mentioned in his description, and, although it is less developed than in *longicollis* or *wadhami,* it is, nevertheless, quite a prominent feature. From a point a little proximal and mesial to this process, there arises a series of spinules which become increasingly multifid (fig. 31, *15m*) dorsi-ventrally, along the edge of peduncle, internal to the inner ramus. Beneath the rami, these are represented by minute toothed spines. The rami are styliform, sub-equal, and the inner rather longer than the peduncle. Both have abruptly sharpened apices, set with a ventral tuft of setae, some quite long.

Occurrence. So far as can be ascertained, this species has been taken only once, when Sayce found it in a small tributary of the Narracan River running through a steep, virgin fern gully. This was described in 1899 as being almost impenetrably dense. Thirty years later, in the hope of obtaining fresh material of *P. gracilis* for comparision with the newly-found *P. longicollis,* a visit was made to Thorpdale, only to find the whole country rolling down-land with scarcely a tree in sight. After prolonged searching, there was found what seemed to be the shrunken creek, and embedded in its bank, the remains of the trunk of a solitary and almost wholly decayed tree-fern; a few blind Amphipods were collected but there was not trace of Phreatoicids. Traced to its source, the creek was found to issue from a very steep slope near the summit of the hill. A little *on the far side of the hill top,* there was a large shallow pool which, the writer was informed, could be drained suddenly by thrusting a long pole into its floor, when it would empty by the creek on the opposite side of the hill. It appears probable that there is some considerable subterranean hollow beneath the lake bed, and here, perhaps, *P. gracilis* may still persist. A wide search over the neighbourhood failed to discover any other likely habitat. It had thus, probably, as restricted a distribution as *Hyperoedesipus.*

Phreatoicoides longicollis, sp. n.

(Figs 32, 33)

Body slender, vermiform, with few short, scattered setae. Pleura of pleon segments not produced, inferior margin of the fifth fringed with a few minute spinules. The total length of pleo-telson about two-fifths that of cephalo-peraeon. Fifth pleon segment distinctly longer than combined length of the four preceding segments. Tailpiece very large, forming more than half of the total length of the pleo-telson, its hinder border shallowly emarginate.

Antennule considerably shorter than peduncle of antenna, with nine or ten joints, peduncle not marked off from flagellum, terminal joints not swollen. Antenna more than two-thirds of the length of the body; peduncle stout, fifth joint longer than the fourth but only about two-thirds of the combined length of second, third, and fourth. Right mandible with vestige of lacinia mobilis. The endite of the maxillula obliquely truncate, bearing three setospines terminally and sub-apically; extremity of outer endite truncate and armed with eleven or twelve spines. Legs slender, seventh pair very long and with thin expanded basis. Peduncle of uropods stout, reaching end of tailpiece, rami as long as peduncle. Dorsally to the base of the rami, there is a stout spine, backwardly produced, nearly half as long as the outer ramus.

Colour. In life, translucent white, with pale yellow patches on head, showing through transparent chitin. In spirit, becoming creamy white.

Length. Longest male 13 mm.; female 9·5 mm.

Habitat. Under small logs in swampy country, near Queenstown in Western Tasmania (February, 1928 and 1929) and on the slope of Mt. Heemskirk, near Zeehan (February, 1929).

Co-types lodged in the Tasmanian Museum.

The following description was based originally on an examination of the one large male and upon dissections of a smaller male (10 mm.) and a mature female (9 mm.); subsequently, many other specimens have been examined.

The *body* is sub-cylindrical, without wrinkles and but sparsely setose, the setae being most evident on the dorsal surface of the tailpiece. In the male, the length is rather more than ten times the greatest width of the peraeon; in the female only about eight times.

The *head*, without trace of eyes, has, in the male, a length approximately equal to its greatest depth and once-and-a-half the length of the first (or twice that of the second) peraeon segment, whereas in the female, the first peraeon segment is so much shorter than the head is about twice the length of that segment. The anterior border of the head is shallowly emarginate; from here, it rises in a high rounded forehead resembling that of *Hypsimetopus*, but behind, the head contracts markedly, particularly in large males, giving the appearance of a 'neck' and recalling the condition seen in some Anthurids and Caprellids. A peculiar feature, particularly noticeable in the larger males of this species is the forward extension of the head to project in front of the labrum, the sub-ocular incisure appearing on this anterior extension as a small notch. A sub-ocular segment is not indicated, but behind the labrum on the ventro-lateral border a second and larger notch lodges the fulcral process of the mandible. The ventro-lateral border of the head is sinuous, nearly horizontal and is not produced behind the mandible into a posterior process. From the ventral margin near its posterior end, a well-marked groove runs upward obliquely, not extending to the dorsal middle line and thus marking off only incompletely from the head a wide posterior region sub-triangular in shape; this is obviously the cervical groove of other Phreatoicids.

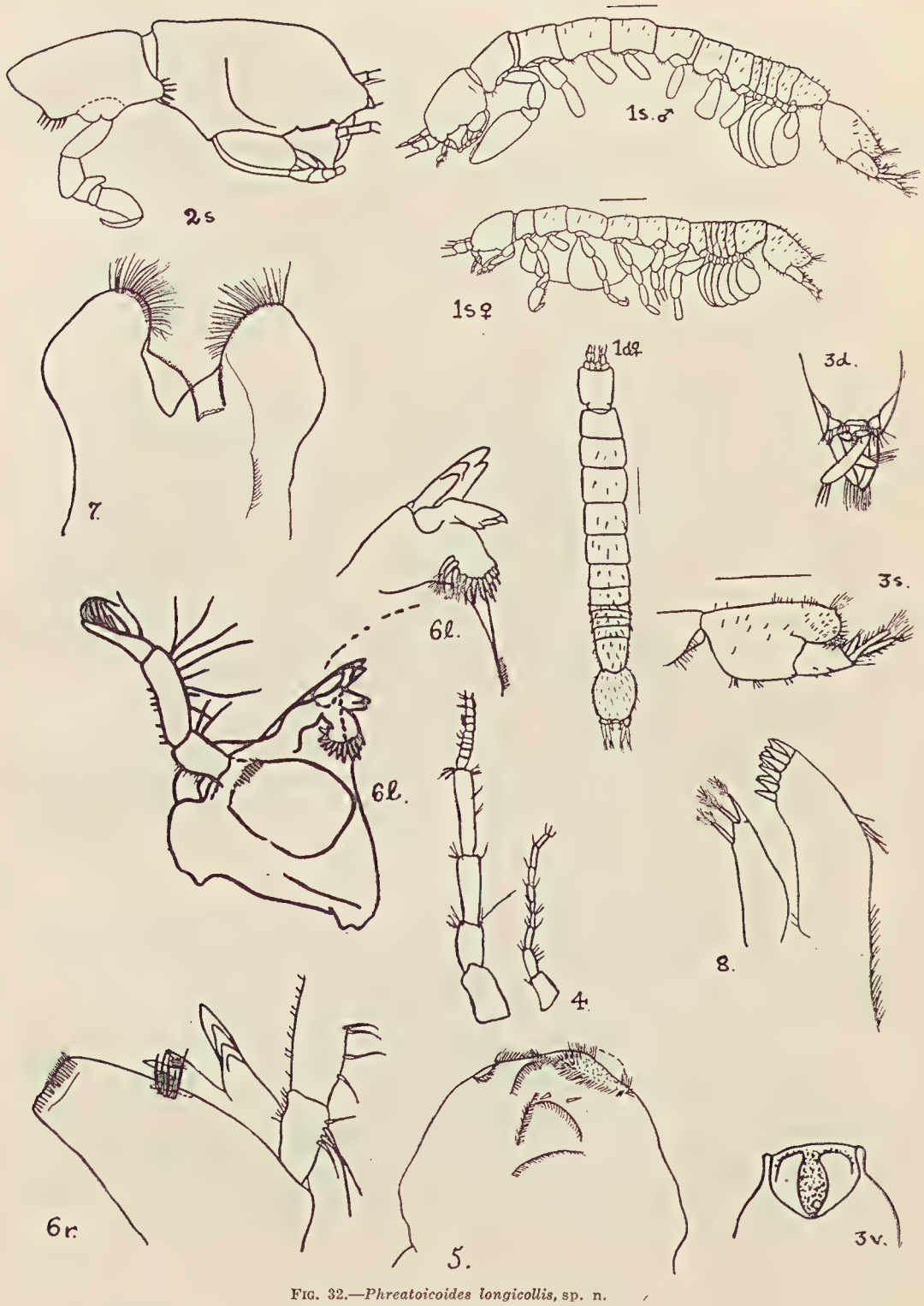

FIG. 32.—*Phreatoicoides longicollis*, sp. n.

Peraeon. In the male, the first peraeon (second thoracic) segment is free and is remakably long, as long as the anterior region of the head (i.e., the part in front of the cervical groove). This is longer than either of the two next succeeding segments which are sub-equal and are followed by three others, also sub-equal but slightly shorter. The seventh peraeon segment is the shortest, having a length of little more than two-fifths of that of the more anterior segments. The sixth and seventh combined have a length equal to that of the first peraeon segment. Similar proportions are found elsewhere only in *Hypsimetopus* but seem to be usual in the Anthuridae. The inferior margin of the peraeon segments appears to be nearly straight. In the female, the first peraeon segment is shorter than the second and the third is the longest. Upon the ventral surface of the thoracic region, the body is produced in the mid-ventral line into a number of prominences, particularly noticeable posteriorly. Sayce has figured somewhat similar structures in *P. gracilis* (1900, pl. X, fig. 1), but they are apparently more strongly developed in the Tasmanian species.

The *pleon* is divided into the usual six segments, but the first four are sub-equal and unusually short, their combined length being about that of the third peraeon segment. They are, indeed, shorter than in any other Phreatoicid, here again recalling the condition of *Apseudidae* and some *Anthuridae*. The fifth pleon segment is, however, rather well developed, having a length almost equal to that of the second peraeon segment. The sixth segment, too, is large, and with the telson makes a massive tailpiece longer than the whole of the rest of the pleon, and having a length equal to, or even slightly exceeding, that of the head. It is nearly once-and-a-half as wide as the rest of the body. Upon the first to fourth pleon segments, the pleura are scarcely developed, thus completely exposing the pleopods. There is, however, a small pleural development upon the fifth and sixth segments, but not sufficient to hide the junction of these two segments, in which region the body is quite markedly constricted. Such an arrangement permits, as Sayce pointed out in his description of *P. gracilis* (1900, p. 127) of a deep ventral flexion of the tailpiece. As noted below, movement is effected by a quick wriggling action of the whole body, but unfortunately no observation was made to determine whether any abrupt backward movement may be effected by the tail-piece. The postero-ventral margin of the pleuron of the fifth segment is fringed with short spinulose setae. Of fringing setae upon the ventral border of the sixth segment, there are none or very few in the male, rather more in the female, but posterior to the insertion of the uropods the ventral margin of the telsonic pleuron is furnished with a number of setae.

Seen from above, the telson appears as a very slightly emarginate body, the actual posterior border of the last tergum being slightly concave, but behind this, the almost transverse end of the body projects slightly. Laterally, the telson is continued into small pleura giving, to a section through the region, a short wide U-shape, a condition closely similar to that described by Sayce in *P. gracilis.*

The *antennule* (fig. 32, 4) is elongate and slender, reaching to the last joint of the peduncle of the second antenna (fig. 32, 4). It consists of nine joints, of which the proximal three may be considered as constituting the peduncle, though there is little to mark them off from the terminal joints which make up the flagellum. In their proportions, these flagellar joints differ somewhat from those of *P. gracilis.* The first and second are short and sub-equal, the third and fourth sub-equal but rather longer, the fifth is long and slender and the last a mere knob. It bears an 'olfactory cylinder' and a tuft of setae, the penultimate joint bearing one or two of these 'cylinders'.

The *antenna* is very long, nearly three-quarters of the length of the body. There are the usual five joints in the peduncle, of which the fifth is relatively much longer than in *P. gracilis* and bears but a few terminal setae. The number of joints in the flagellum is about twenty-five, but many of the articles appear to have been about to undergo division, perhaps in anticipation of the next ecdysis. The first and second are short, the third and fourth still shorter and they continue short till the ninth. The tenth is longer and appears to include two and they so continue, increasing in length, to the seventeenth. In the eighteenth, three articles are indicated. To the twenty-fourth, there are two pieces, while the last is but a simple piece. Each joint has a distal circlet of setae but the components are without setae; if these really represented separate articles, the flagellum would have as many as forty-six joints.

Labrum. This is, as usual, markedly asymmetrical; the ventral border is very sparsely setose (fig. 32, *5*).

The *mandibles* are short and stout. In the left mandible (fig. 32, *6l*) the primary dentate edge has four strong teeth, the lacinia is well-developed and has three dark, heavily chitinized teeth; spine row broad with numerous denticulate spines but three or four of the more distal are setospines; the molar short with rounded sub-quadrangular grinding surface. An acetabular process is developed, but the fulcral process was not seen. The right mandible (fig. 32, *6r*) differs noticeably in the great reduction of the lacinia, which is little more than a stout, two-pronged spike, scarcely separated from the spine row. Occasionally, a minute third tooth appears as a small, bent projection between the two longer teeth. The principal cutting edge has four teeth. The right molar is much longer and more slender than the left.

The *labium* (fig. 32, *7*) has inner lobes which are fringed only with short, fine setae; the large outer lobes are setose only apically and mesially.

The *maxillula* (fig. 32, *8*) shows almost the maximum degree of reduction in the proximal endite, on which there are never more than three setospines, while one or usually both of the two simple spines so generally present to Phreatoicidae are absent. The endite is narrow and may even taper to a point, the setospines almost mesial in position. The outer endite has the shape characteristic of *Synamphisopus*, being sharply bent at about its mid-point and armed apically with about a dozen stout spines. The sub-terminal plumose setae on the face of the endite are also missing.

The *maxilla* (fig. 33, *9*), too, has undergone considerable reduction. The basal part of the proximal endite is variable but usually projects slightly and carried a short fringe of filter setae backed by four or five[1] stout setae from which the pectinations normally developed are practically wanting. The distal part of the endite is long relatively, much of its mesial border free from setae, but densely armed apically with simple and biting setae. Of the two distal endites, the inner may be quite narrow and short, the outer much wider, or they may be of almost equal length, each carrying a mixed series of denticulate and simple setae.

In the *maxilliped* (fig. 33, *10ml*) the features to be noted are the relatively large sub-ovate epipodite produced to a blunt point much as in *Hypsimetopus*, setose only near its mesial border, the short basis with its endite armed mesially with a few (six or seven) brush setae and an apical series of short plumose setae; the palp rather short, with carpus mesially expanded, propod almost circular, the dactyl flattened and narrow, with few setae, practically all springing from its mesial border. One or two coupling hooks may be present. In the female, the

[1] Seven on the left appendage, and nine on the right, in one female.

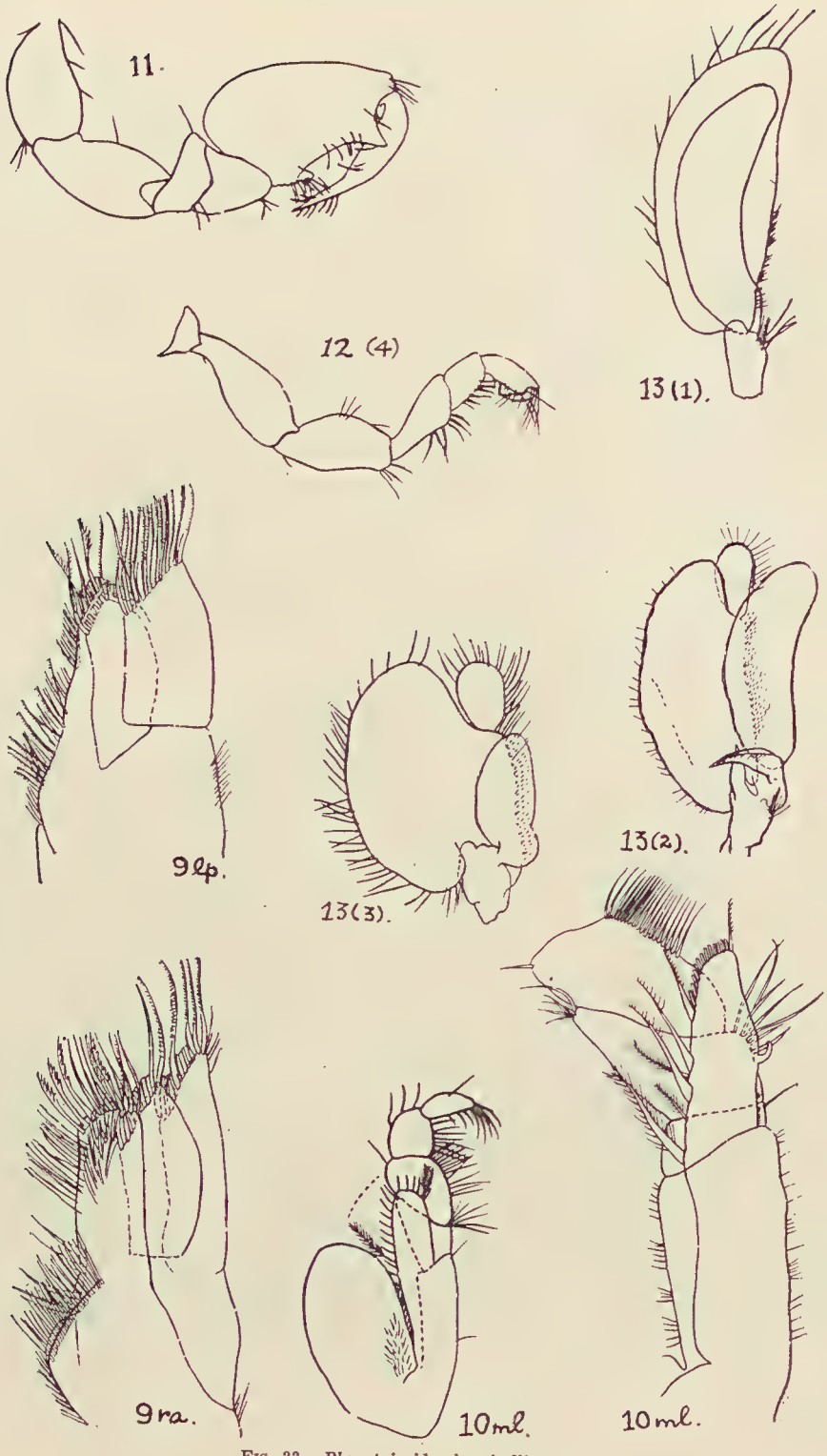

FIG. 33.—*Phreatoicoides longicollis*, sp. n.

coxal lobe is large. It is carried vertically, projecting obliquely into the brood-pouch, the anterior lobe of the first oostegite lying as usual externally to it and sheathing the coxa of the maxilliped. The free lateral border of the coxal lobe bears mesially some half-dozen short curved setae and, more laterally, as many but much longer and very flexible setae.

Gnathopod. Male (fig. 33, *11*), ischium as long as basis, merus produced antero-distally, the propod very stout, with anterior border convex, the palm produced into a great spine proximally and a second even longer, at the distal end of the palm which, between these spines, is slightly concave; dactyl is strong near its base but narrows abruptly near its tip; it is almost as long as the posterior border of the propod, its apex coming to rest against the setose posterior surface of the proximal spine. In the female, the proportions of the joints are much the same, except for propod and dactyl, both of which are but moderately developed.

Peraeopods. The sexual modification of the male fourth peraeopod (fig. 33, *12(4)*) is very slight, for, although this appendage is sub-chelate, the propod hardly differs from that of preceding appendages.

The *pleopods* have undergone very considerable reduction. The first (fig. 33, *13(1)*) has a fairly long sympodite carrying four or five entangling setae on its mesial border; the exopodite is slightly longer and nearly twice the width of the endopodite and bears a few fringing setae on the convex lateral border and also a few simple setae proximally on the mesial edge. The endopodite is quite bare of setae. In the second pleopod (fig. 33, *13(2)*) there is a small mesial coupling lobe on sympodite with about seven long setae; the exopodite resembles that of the first appendage, except that there is a short distal lobe and that the mesial setae are less abundant; the endopodite has a rounded basal lobe from which springs the outer respiratory lamella, and mesially, in the male, a very stout penial stylet. This tapers strongly to a narrow apex, is without terminal setae, but bears a few (four or five) marginal spinules. The succeeding pleopods bear, on the sympodite, pronounced mesial coupling lobes, but are without epipodites. In the two hindermost the exopodites are noticeably shorter and wider, the endopodites become narrower but reach always to the base of the distal lobe of the exopodites (fig. 33, *13(3)*). On the latter, plumose setae are generally wanting, but strong simple setae line the short mesial border of the proximal lobe and rather longer setae fringe the outer border.

On the *tailpiece* (fig. 32, *3s*) a tuft of long terminal setae arises from the flattened surface *beneath* the transverse posterior border; the telsonic pleura are convex, somewhat produced. Their surface is markedly setose. A short suture is continued forwardly from the dorsal border of the uropod but bears no spines or setae; the ventro-lateral border of the sixth pleon segment anterior to the uropods has two or three tufts of short setae.

The *uropods* (fig. 32, *3d*) are styliform; the peduncle is short and deep, extending scarcely behind the posterior end of the body; the rami long and sub-equal, the outer a little the shorter, but as long as the peduncle, the whole appendage bearing many long setae. From the mid-dorsal border, between the rami, rises a short stout spine.

Occurrence. These Phreatoicids were first taken in open 'button-grass' country, by the side of a narrow-gauge railway about three miles from Queenstown, This one-time ore line now serves the electric power station below Lake Margaret, and even in midsummer, this patch of country is usually extremely wet, water lying to the depth of an inch or so over considerable areas and slowly draining

into a sphagnum-choked ditch by the side of the line.[1] Across this wet country an old 'corduroy track' composed of stout sticks and stems of saplings, many well advanced in decay, led away in a north-westerly direction towards Zeehan.[2] These poles were partially embedded in firm mud and for the most part under water, there being a much more evident flow along this trail. It was on the under surface of these partially-decayed logs that the specimens were obtained. On disturbing the logs, the isopods at once dropped off, travelling quickly in the trickling muddied water by an active wriggling movement of the whole body. By accident or design, many reached one or another of the numerous gaping mouths of burrows (probably those of an *Engaeus*) down which they passed at once from sight. A single log commonly harboured several, but of these it was rare to secure more than one or two, their successful escape being the more surprising in view of their blind condition and inability to swim in the more usual direct Isopod fashion. An attempt to dig them out proved quite unsuccessful, the mud at a foot below the surface being practically liquid. It is of interest to note that all of the specimens secured were taken in the early forenoon (February 6th). None were seen on the occasion of the first search at this spot in the late afternoon of the previous day, nor again at a somewhat early hour in the afternoon of February 6th. An explanation which suggests itself is that this Phreatoicid (like *Hypsimetopus*) normally shares the burrows of *Engaeus* from which it emerges periodically to feed on the decaying surface of these logs. On the other hand, the association may be a purely accidental one and their escape into these holes may have been due to in-sinking currents which swept them into safety. Both the *Engaeus* and these semi-terrestrial Phreatoicids are obviously restricted to localities almost permanently waterlogged, where they live practically at, or very near, the surface but it may be the case in *Hypsimetopus*, as in that of *Phreatoicoides gracilis*, that life above ground under decaying wood or within its crevices is the normal condition and that only when forced underground by conditions of exceptional dryness, or when disturbed, do these creatures take refuge within the 'land crab' burrows. It seems likely that the association is a wholly casual one.

The inclusion of these notes seems warranted in the interest of those who may engage in the search for such cryptozoic forms. The country-side in which they occur is one in which precise landmarks are not readily available and for the lack of guidance, days may be wasted on fruitless searching. The presence of the writer in this particular district was due, amongst other things, to an attempt to rediscover *Hypsimetopus*. This Phreatoicid was found, apparently quite accidentally, more than forty years ago and three specimens were sent (by whom it has proved no longer possible to discover) to Professor Haswell and, subsequently, described by Sayce (1902). The locality is given as 'Near Zeehan, Tasmania, in burrows of *Engaeus cunicularis*'. During the summers of 1928 and 1929, and again in 1939, several days were spent in and around Zeehan in an entirely fruitless search for this species *(H. intrusor)*[1] and, at the present time, one male specimen in the National Museum, Melbourne, apparently constitutes the entire available material,

As regards *Phreatoicoides longicollis*, eighteen specimens were secured, on the first occasion, in an hour's collecting. Of these, four were males, ranging in length, when preserved, from 6 mm. to 11·5 mm. All of these showed the very characteristic hand quite well developed, although, in two examples, one of the gnathopods

(1) It was in this patch of sphagnum that the Syncarid, *Micraspides calmani*, was first discovered.

(2) In 1939, the occasion of the last visit, it was found that conditions were largely disturbed by the cutting of the new road from Queenstown to Zeehan.

(3) A curious coincidence is the close external likeness of *longicollis* to *Hypsimetopus*.

had recently been lost. In one of these, a very small limb had regenerated and upon this, the 'hand' was still in a quite immature state. Eight others were visibly female, six being provided with a fully-grown, but empty, brood-pouch, the other two having the oostegites as narrow firm lamellae adpressed to the ventral body wall. The largest female obtained at that time reached a length of 8·5 mm.

In 1929, the collecting area was extended and both *Micraspides* and *Phreatoicoides longicollis* were again taken, once in boggy country thirteen miles (by road) south-east of Queenstown and later, a dozen miles or so to the west of Zeehan, on the southern slopes of Mt. Heemskirk. Some of the *Phreatoicoides* reached a rather greater length, but no ovigerous females were taken. In succeeding years, other attempts were made fruitlessly by a student from the University of W.A. to rediscover these species, and in 1939 the writer revisited the original localities and many new ones, but with no success. It seems evident that only under the normally very wet conditions can such collecting be attempted with any hope of success and on every occasion *Hypsimetopus* has eluded us.

For *Phreatoicoides gracilis*, Sayce (1900, p. 125) found that the ratio of pleo-telson to cephalo-peraeon was but 36 to 100, and these proportions were stated to be invariable (l.c., p. 137). It is to be assumed that Sayce's measurements were made upon a number of fully-grown specimens, but there is no statement whether or not this ratio measurement was obtained from living (or freshly-killed) specimens. If that were the case, the proportions of these two body regions would be almost identical with those obtaining in living *P. longicollis*. A considerable shrinkage in length takes place during preservation in spirit, sometimes resulting in the almost complete obliteration of the intersegmental regions. In life, these are quite notable, particularly in the peraeon, so that measurements made upon the living animal would show an even greater disproportion between the cephalo-peraeon and the pleo-telson regions. An examination of the smaller specimens of *P. longicollis* suggests that this disproportion increases with the increase in total length. Thus, in a male of 8·5 mm., the ratio of pleo-telson to cephalo-peraeon is approximately 43 to 100, whereas in the largest specimen this ratio has fallen to barely 40 to 100. Miss Sheppard (1927, p. 84) notes that in an example of *P. gracilis* which she examined, the ratio was 46 to 100. Her specimen was presumably one which had been in preserving fluid and for many years, and which had undergone the maximum shrinkage. It is possible, moreover, that this specimen was not fully-grown and had not attained, therefore, mature proportions.

As Chilton (1916) has pointed out, too much reliance must not be placed upon such measurements, as these may, perhaps, vary with age, and be different in the two sexes. Moreover, these measurements are by no means easy to determine with accuracy nor may one too confidently base comparisons upon the strength of measurements made from published drawings, since these may easily prove misleading. But there can be no warrant for questioning the accuracy of Sayce's measurements in the case of *P. gracilis*, in view of his statements above quoted, and it is thus of considerable interest to find his figures agreeing so very closely with those obtained from the full-grown specimen of *P. longicollis*.

The most striking feature in the male of all these species of *Phreatoicoides* is the marked reduction in length of the first four pleon segments and a narrowing of the anterior five, associated with an increase in width in the tailpiece. This is particularly noticeable in *P. longicollis*, although the fifth segment is relatively rather large; it is seen also in the immature female. It is evidently a development

peculiar to this genus and, perhaps, to *Hypsimetopus*; there is just a hint of it in *Hyperoedesipus*. There is no suggestion of such a widening in the tailpiece in the vermiform New Zealand species.

Phreatoicoides wadhami, sp. n.

(Fig. 34)

Body (fig. 34, *1*) slender, vermiform, almost free from setae; the head much longer than deep but less than the combined length of the first and second peraeon segments, with strong ridge running around the anterior region and continued along the ventro-lateral border; cervical groove only faintly indicated; first to fourth peraeon segments sub-equal, fifth, sixth, and seventh progressively shorter and deeper; pleon with pleura scarcely developed, first to fourth segments short, with few fringing setules, fifth segment as long as the combined length of the four preceding segments; pleuron restricted to the anterior half of the ventral border, with few setules; tailpiece rather less than half of pleo-telson.

Antennule (fig. 34, *4*) shorter than peduncle of antenna with ten or eleven joints; joints of peduncle sub-equal, but first joint expanded laterally, flagellum almost filiform, joints elongate, terminal joints not swollen. *Antenna* (fig. 34, *4*) very long, reaching to fourth pleon segment, flagellum with sixty-six joints. Right *mandible* (fig. 34, *6r*) with lacinia mobilis reduced to a single spike.[1] *Maxillula* (fig. 34, *8*) with setospines along inner border of proximal endite. *Gnathopod* with very strong hand, dactyl (fig. 34, *11l*) stout, carrying numerous strong setae. Fourth *peraeopod* subchelate.

Pleopods. First pleopod (fig. 34, *13(1)*) practically the entire border setose; a few plumose setae latero-distally; penial stylet on second pleopod slender, endopodites long on all but the fifth; distal lobe of exopodite not reduced.

Uropods (fig. 34, *15*) stout, styliform, the distal process of peduncle projecting above and between the rami, a row of spinules running obliquely from the middle of the dorsal surface to the *outer* distal angle; rami rod-like, truncated apically to end in a sharp point, the inner bearing a terminal tuft of long setae.

Colour. Whitish, translucent in life.

Size. 9 mm. male.

Locality. Beechforest—Otway Mts. (Victoria).

The description is unfortunately incomplete, only a single male, somewhat damaged and almost certainly immature, being available for examination. This was found in sphagnum which had been used as packing for a number of *Phreatoicopsis terricola*, sent alive by air-mail in the early summer of 1937. The same moss contained one example of *Trichoniscus* sp. as well as a number of planaria and *Geonemertes* sp. In January, 1939, an attempt was made to obtain further specimens, but proved fruitless.

The specific name proposed is in compliment to Professor Wadham, by whom the material was collected.

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[1] Which may be bifid.

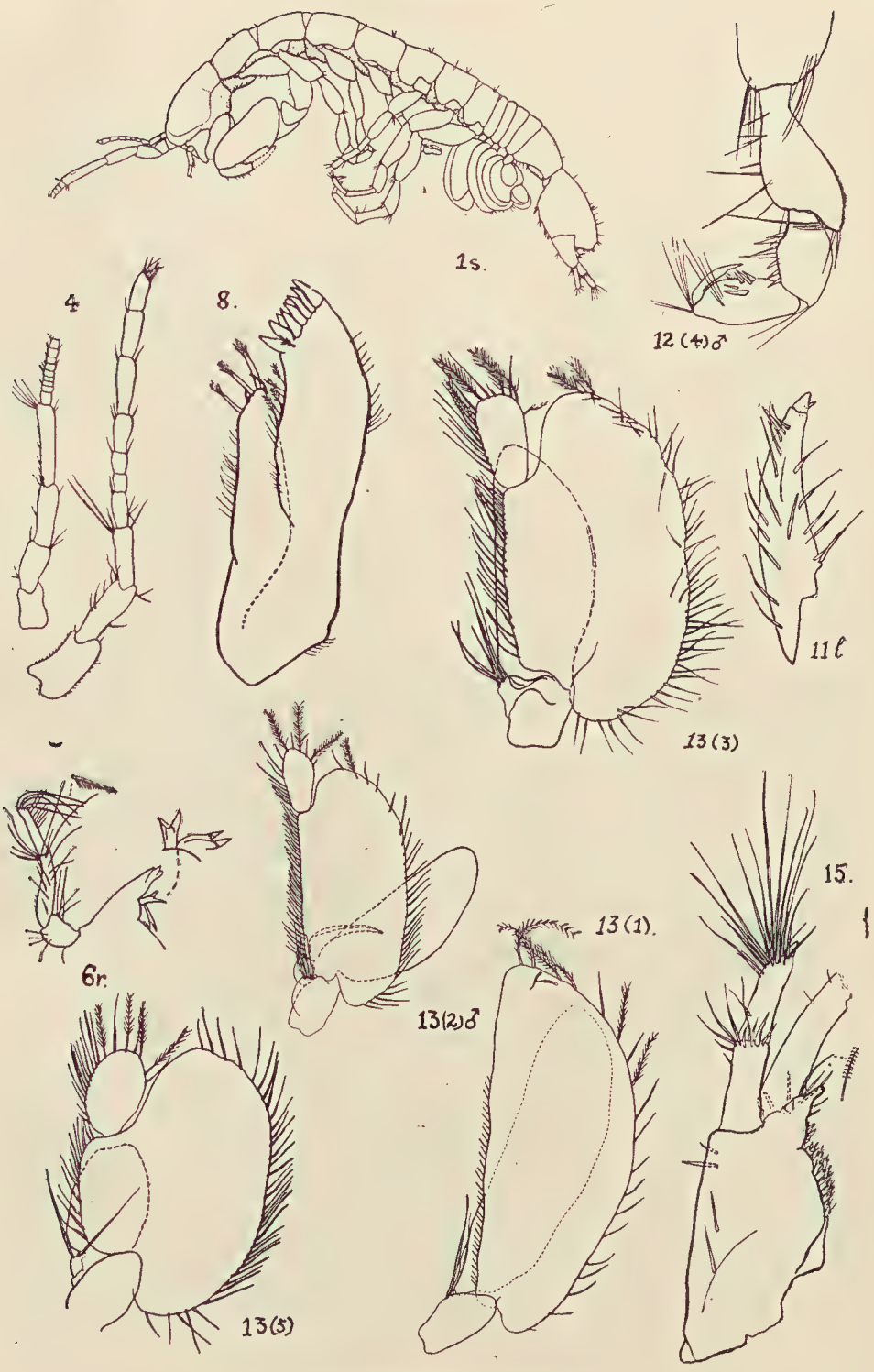

FIG. 34.—*Phreatoicoides wadhami*, sp. n.

Pap. & Proc. Roy. Soc. Tasmania, 1942 (16th August, 1943.)

On some new Hadrotarsidae (Araneae) with Notes on their Internal Anatomy

By

V. V. Hickman

(Read 25th November, 1942)

Plates I-V

The family Hadrotarsidae contains only two species, namely, *Hadrotarsus barbirussa* Thorell from Yule Island, New Guinea, and *Gmogala scarabaea* Keyserling from Sydney, New South Wales. Thorell (1881, p. 190) appears to have had only two specimens of *H. barbirussa*, one a male, the other a female. He has given a detailed account of the male, but the female was damaged before he was able to complete the description and therefore very little is known of its characters. Keyserling's account of *Gmogala scarabaea* is based on a female specimen which was later lodged in the British Museum. Pocock (1903, p. 619) re-examined the specimen, and offered some supplementary remarks on the genus. He came to the conclusion that Keyserling's description was 'defective in many points, erroneous in others', and that the two genera, *Hadrotarsus* and *Gmogala*, were identical.

Hadrotarsidae are particularly rare. Rainbow (1902, p. 315) states that there is a single female specimen of *G. scarabaea* in the Australian Museum, Sydney. This appears to be the only Hadrotarsid in any museum in Australia. When Simon wrote his comprehensive work he had no specimen of this family for study and was forced to rely on the descriptions given by Thorell and Keyserling. More recently Petrunkevitch (1933, p. 305) remarked that no specimens of Hadrotarsidae were 'available in any museum in the world for anatomical studies'. It follows, therefore, that our knowledge of this group is very deficient. Some authorities have suggested abandoning the Hadrotarsidae and transferring the genera *Hadrotarsus* and *Gmogala* to other families (see Berland, 1932, p. 359, Crosby, 1934, p. 21, and Gerhard and Kästner, 1938, p. 592).

The present paper deals with three new species which, in my opinion, belong to the genus *Hadrotarsus* and justify the retention of the family Hadrotarsidae. The main features of the internal anatomy of two of the species are described and a new definition of the family is given.

Order ARANEAE

Sub-order *DIPNEUMONOMORPHAE*

Family HADROTARSIDAE

Genus **Hadrotarsus** *Thorell*, 1881

Hadrotarsus ornatus, sp. n.

Male. Measurements in millimetres:—

Total length	1·5660
Length of cephalothorax	0·4932
Width of cephalothorax	0·6165
Length of abdomen	1·2330
Width of abdomen	1·0412

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0·3425	0·2055	0·2877	0·1781	0·3151	1·3289
2	0·2740	0·1918	0·2603	0·1644	0·3014	1·1919
3	0·2603	0·2055	0·2466	0·1712	0·2877	1·1713
4	0·3562	0·2603	0·3151	0·2192	0·3425	1·4933
Palp	0·1781	0·1096	0·0685	....	0·4110	0·7672

Colour. Carapace yellowish brown with narrow black lateral margins and a black reticulate pattern behind eyes. Ocular area black anteriorly. Legs yellowish brown becoming darker towards the apex. Chelicerae, palpi, labium, maxillae, and sternum yellowish brown. Dorsal shield of abdomen yellowish brown crossed by four transverse black bands, which are interrupted in the middle. Ventral sclerites yellowish brown.

Carapace. Wider than long, somewhat narrowed in front, emarginate behind and with well-rounded sides. Thoracic groove wanting. Radial grooves faintly marked. Head part moderately high. From behind PME the carapace slopes gradually to the posterior margin. Surface smooth, shining and almost glabrous (pl. I, fig. 1).

Eyes. Viewed from above the eight eyes are seen to be arranged in two rows. The front row appears slightly recurved. Viewed from in front the anterior row is distinctly procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is strongly procurved (pl. I, fig. 2). The eye ratio AME : ALE : PME : PLE = 5 : 5 : 8 (long) : 5. AME are on a small tubercle and are separated from each other by $\frac{2}{3}$ and from PME by $\frac{2}{5}$ of their diameter. They are in contact with ALE, which are in contact with PLE. PME are large, reniform, and flat. They are almost contiguous with each other, but separated from PLE by a space equal to the diameter of AME. The width of the eye-group is slightly less than the width of the carapace in the region of the eyes. The quadrangle formed by the median eyes is wider in front than behind in ratio 12 : 9. Its length is greater than its anterior width in ratio 14 : 12. The AME are dark, the other eyes pearly white. The height of the clypeus in front of AME is about 18/5 of diameter of AME.

Chelicerae. Small, conical, vertical, and without lateral condyles. Their inner edges obliquely diverging, devoid of teeth and scopula, but furnished with a row of three straight setae near the base of the fang. The fangs are moderately long and falcate. They lie transversely and cross each other (pl. I, fig. 3).

Maxillae. Triangular, converging in front of labium. Their inner ends pointed and membranous. A serrula consisting of eleven teeth is situated on the antero-lateral margin. The inner margin has a short scopula (pl. I, fig. 4).

Labium. Triangular, rounded and membranous in front. Wider than long in ratio 7 : 5. Furnished with three pairs of setae (pl. I, fig. 4).

Sternum. Convex, rounded and triangular. Width equal to length. The posterior end truncate. Fourth coxae separated by slightly more than their width. Middle of sternum glabrous, but its sub-marginal region is clothed with a few hairs which point inwards (pl. II, fig. 13).

Legs. 4.1.2.3. The first pair of legs with swollen tarsi. The joint between tarsus and metatarsus in both the first and second pairs of legs not constricted (pl. I, figs 5 and 6). Integument is clothed with barbed hairs. These are coarser and more numerous on the tarsi than elsewhere, especially on the ventral surface of the first tarsi. Spines and scopulae are wanting. Each leg has three trichobothria; one on the metatarsus near the apex and two on the tibia, one of which is near the middle, the other near the base. Two tarsal claws situated on a short onychium are present. The prolateral and retrolateral claw of each leg, excepting those of the fourth pair, are pectinate on both promargin and retromargin. The number of teeth and their arrangement differ on the different claws, as is indicated in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	12	1	10	1
Leg 2	11	1	9	1
Leg 3	10	1	1	8
Leg 4	8	0	0	8

The pectination of the claws of the first, third, and fourth pairs of legs is shown in pl. I, figs 7, 8, and 9. At least one pair of barbed setae on each tarsus appear to act as spurious claws.

Palpi. Moderately long. Cymbium spoon-shaped. Tibia short and saucer-shaped, devoid of apophyses but provided with a single trichobothrium. Patella short. The genital bulb has the form shown in pl. I, fig. 10. It is provided with a long, coiled embolus which makes two complete turns in the basal half of the cymbium and then passes round the retrolateral margin and apex to make a complete turn in the distal half of the cymbium. The tip of the embolus projects slightly on the prolateral side. Parallel with the end of the embolus is a hard, slender, terminal apophysis, which is provided with a few minute teeth on one side (pl. I, fig. 11). Near the tip of this apophysis is a small hook-like projection on the cymbium. Under high magnification the embolus is seen to have a small barb near the tip (pl. I, fig. 12).

Abdomen. Ovate, covered dorsally by a hard shield, which has a narrow V-shaped notch in the middle of its anterior margin. On both sides of the notch are a few coarse spine-like setae. The rest of the shield is lightly clothed with fine, short hairs. The front of the abdomen overhangs the carapace. The anterior half of the ventral surface is covered by a large epigastric scute, which extends forward and surrounds the pedicle. The lung covers are incorporated in the scute

and appear as a pair of long oval patches, one on each side. The epigastric furrow lies immediately behind the epigastric scute. The two lung slits are situated in the furrow, one on each side. Behind the furrow is a small median sclerite, on each side of which is a slightly larger lateral sclerite fused to the epigastric scute round the outer end of the lung slit. These two lateral sclerites partly overlap the posterior edge of the epigastric scute, thus hiding part of the epigastric furrow (pl. II, fig. 13). Behind the median and lateral sclerites is a large ventral scute, which covers most of the posterior half of the ventral surface. Near the antero-lateral angles of this scute is a pair of small rounded sclerites, one on each side. Attached to the posterior edge of the ventral scute and immediately in front of the spinnerets is a small median sclerite, on which is situated the single tracheal spiracle. The integument at the sides of the abdomen exhibits a series of three longitudinal folds, two of which are continuous anteriorly above the pedicle and posteriorly above the anus. The two most ventral folds on each side are reinforced with a number of small sclerites which tend to fuse together forming irregular longitudinal bars. Posteriorly, some of the bars unite with the ventral scute and with one another so as to form a hard chitinous ring almost surrounding the spinnerets.

Spinnerets. Six. The anterior pair short, conical, and close together. Each consists of a basal segment and a small apical segment. The inner surface of the basal segments thickly chitinized and marked with fine transverse ridges to form what is probably a stridulating organ. The small apical segment is furnished with three long, slender, spinning tubes (pl. II, fig. 14). The middle spinnerets are very small and not visible unless the other spinnerets are parted. Each consists of a single narrow segment provided with one spinning tube (pl. II, fig. 16). The posterior spinnerets are short, conical, and two-segmented. The apical segment is provided with a very wide spinning tube or spigot and two slender tubes (pl. II, fig. 15). A colulus is wanting.

Female. Measurements in millimetres:—

Total length	1·8084
Length of cephalothorax	0·5891
Width of cephalothorax	0·6165
Length of abdomen	1·2878
Width of abdomen	1·0459

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0·3562	0·2192	0·2603	0·1781	0·3014	1·3152
2	0·3425	0·2055	0·2329	0·1781	0·2877	1·2467
3	0·3151	0·2055	0·2329	0·1781	0·2877	1·2193
4	0·3973	0·2603	0·2945	0·2192	0·3425	1·5138
Palp	0·1370	0·0616	0·1233	....	0·1781	0·5000

The female resembles the male in coloration, markings, and general appearance. Hence only the following features need be described: —

Eyes. The eight eyes are arranged as in the male. The width of the eye-group is less than the width of the carapace in the region of the eyes in ratio 20 : 25. Viewed from above, the front row of eyes is almost straight, but viewed from the front it is procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is strongly procurved. Ratio of eyes AME : ALE : PME : PLE = 4 : 5 : 7 (long) : 5. AME are slightly smaller than in the male. They are separated from each other by ¾ and from PME by 2/4 of their diameter. They are in contact with ALE, which are in contact with

PLE. PME are large, flat, and reniform. They are almost contiguous with each other but separated from PLE by a space equal to the diameter of AME. The median ocular quadrangle is wider in front than behind in ratio 11 : 9. Its length is greater than its anterior width in ratio 15 : 11.

Labium. Triangular, rounded in front, wider than long in ratio 9 : 4, provided with seven setae.

Chelicerae and *Maxillae.* As in the male.

Sternum. Convex, rounded, and triangular. Longer than wide in ratio 28 : 26. Clothed with a few sub-marginal hairs which point inwards. Posterior end truncate. Fourth coxae separated by slightly more than their width.

Legs. 4.1.2.3. As in the male, but the tarsal claws show slight differences in the number of teeth. See following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	12	1	11	1
Leg 2	12	1	9	1
Leg 3	9	1	1	9
Leg 4	8	0	0	8

Palpi. Clothed with barbed setae but devoid of spines. One trichobothrium on tibia, elsewhere none. The single tarsal claw has eleven teeth on the promargin and one on the retromargin. The claw is so curved that the row of teeth on the promargin is almost transverse to the long axis of the tarsus, and the claw appears like a minute rake (pl. II, fig. 17).

Abdomen. Ovate, and provided with a hard dorsal shield as in the male. The scutes on the ventral surface, however, are somewhat different from those of the male (pl. II, fig. 18). There is a large ring-like sclerite surrounding the base of the pedicle, the ring being wider anteriorly than posteriorly. Behind the ring is a moderately large rectangular median scute occupied by the epigynum. On each side of this median scute, but separated from it, is an elongated pulmonary sclerite protecting the book-lung. The openings of the book-lungs lie, one on each side, between the pulmonary sclerite and a smaller sclerite, which is partly fused to its posterior margin. Behind the epigynum is a small median rectangular sclerite, on each side of which and behind the postero-lateral angle of the pulmonary sclerite are two small lateral sclerites situated one behind the other. The posterior half of the ventral surface is covered by a large ventral scute. Attached to the posterior margin of this ventral scute and immediately in front of the spinnerets is a small sclerite on which is situated the tracheal spiracle. The longitudinal lateral folds reinforced with sclerites as described in the male also occur in the female.

Spinnerets. Similar to those of the male and provided with similar stridulating ridges on the anterior pair.

Epigynum. The form of the epigynum in surface view is shown in pl. II, fig. 19, and as a transparent object in pl. V, fig. 39.

Habits. Specimens kept in the laboratory did not spin a web or make any nest. The spider occurs in grass-tussocks, moss, and other situations close to the ground, and is usually found during the months May to September.

Localities. The type specimens were found in grass-tussocks on the eastern slopes of the Domain, Hobart. Co-types were collected at Glen Dhu, the Punch Bowl, and Trevallyn, near Launceston.

Hadrotarsus fulvus, sp. n.

Male. Measurements in millimetres:—

Total length	1·3974
Length of cephalothorax	0·4932
Width of cephalothorax	0·4658
Length of abdomen	0·9727
Width of abdomen	0·6028

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0·3699	0·2055	0·3014	0·1644	0·3014	1·3426
2	0·3014	0·1918	0·2603	0·1507	0·2877	1·1919
3	0·2740	0·1918	0·2466	0·1507	0·2740	1·1371
4	0·3699	0·2329	0·3562	0·2055	0·3562	1·5207
Palp	0·1918	0·0822	0·0411	....	0·2548	0·5699

Colour. Yellowish brown without markings. Ocular area black anteriorly. Two dorsal muscle spots on abdomen.

Carapace. Almost as wide as long (pl. III, fig. 20). Thoracic groove wanting. Clothed with a few minute scattered hairs, otherwise the surface is smooth, shining and glabrous.

Eyes. The eye-group occupies about $\frac{2}{3}$ of the width of the carapace in the eye-region. The eight eyes are arranged in two rows. Viewed from above the front row appears slightly recurved. From the front it is seen to be strongly procurved. The posterior row is procurved. PME large, flat, and reniform. AME dark, the other eyes pearly white. Ratio of eyes AME : ALE : PME : PLE = 3 : 3 : 6 (long) : 3. AME separated from each other by $\frac{2}{3}$ of their diameter and from PME by about the same distance. ALE in contact with both AME and PLE, forming a crescent-shaped row. Height of clypeus in front of AME is about twice the diameter of AME.

Chelicerae. Conical, small, and vertical. Their inner edges obliquely diverging. Lateral condyles, teeth, and scopula wanting. A row of three straight setae near base of fang. Fangs moderately long and falcate. They lie transversely and cross each other (pl. III, fig. 23).

Maxillae. Converging in front of labium. Apex pointed, membranous, and pellucid. A serrula consisting of a row of eight teeth is situated on the antero-lateral margin, and a small scopula on the inner margin near the apex.

Labium. Triangular with apex rounded. Wider than long in ratio 5 : 4. Provided with three pairs of setae. The apex is colourless and difficult to see.

Sternum. Shield-shape, convex, longer than wide in ratio 25 : 23. The posterior end is truncate and separates the fourth coxae. The middle of the sternum is smooth and glabrous, the sub-marginal region clothed with a few setae which point inwards (pl. III, fig. 24).

Legs. 4.1.2.3. Tarsi of first pair of legs swollen. Integument lightly clothed with barbed hairs. Two trichobothria on each tibia and one near the apex of each metatarsus, elsewhere none. Spines absent. Metatarsi much shorter than tarsi. Tarsal claws two, situated on an onychium, which also carries a pair of barbed hairs resembling spurious claws. Claws of the first three pairs of legs pectinated on both margins, those of the fourth pair on one margin only. The number of teeth on each claw is given in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	10	1	9	1
Leg 2	9	1	8	1
Leg 3	9	1	1	6
Leg 4	7	0	0	6

Scopulae and claw tufts wanting.

Palpi. The form of the right palpus is shown in pl. III, figs 21 and 22. The tibia is very short, saucer-shaped, and without apophyses. It has a small trichobothrium. The cymbium is very large and the alveolus is on the retrolateral side. The embolus is long and thread-like. It arises on the retrolateral side, and passes down and round the margin of the cymbium. It then curves back and ends near its point of origin on the retrolateral side.

Abdomen. The dorsal surface is covered by a hard chitinous shield, which has a small median V-shaped notch in the anterior margin (pl. III, fig. 20). On each side of the notch are a few short, thick setae. Elsewhere the scute is lightly clothed with small hairs. There is a pair of large conspicuous muscle spots near the middle of the scute. The front half of the ventral surface of the abdomen is covered by a large epigastric scute, which anteriorly surrounds the base of the pedicle (pl. III, fig. 24). Immediately behind the posterior margin of this scute is the epigastric furrow, in which lie the pulmonary spiracles, one on each side. Behind the furrow is a transverse row of three small scutes, the two lateral ones of which are fused to the epigastric scute round the outer ends of the pulmonary spiracles. The posterior half of the ventral surface is mainly covered by a large ventral scute, near the antero-lateral angles of which is a pair of very small sclerites, one on each side. Between the ventral scute and the spinnerets is a transverse row of three small sclerites, the middle one of which bears the tracheal spiracle, which is immediately in front of the spinnerets. The lateral sclerites in the row sometimes show a tendency to fuse with the large ventral scute, but in most cases they are quite separate. On each side of the abdomen below the dorsal shield the integument forms three longitudinal folds, two of which are continuous anteriorly above the pedicle and posteriorly above the anal tubercle.

Spinnerets. Six. There is a small sclerite on each side of the spinnerets, but the group is not surrounded by a chitinous ring. Anterior and posterior spinnerets are two-segmented, the apical segment being very short and conical. As in *H. ornatus* the inner surface of the basal segment of each anterior spinneret is marked by a series of fine transverse ridges to form what appears to be a stridulating organ. (Pl. III, fig. 27, shows the anterior spinnerets of the female,

which are similar to those of the male.) The middle spinnerets are very small and one-segmented. The posterior spinnerets are provided with a spigot having a very wide tube.

Female. Measurements in millimetres:—

Total length	1·4248
Length of cephalothorax	0·5206
Width of cephalothorax	0·4521
Length of abdomen	0·9316
Width of abdomen	0·6302

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0·3699	0·2055	0·2603	0·1507	0·2466	1·2330
2	0·3151	0·1781	0·2329	0·1507	0·2603	1·1371
3	0·3014	0·1781	0·2192	0·1507	0·2740	1·1234
4	0·4110	0·2329	0·3425	0·2055	0·3288	1·5207
Palp	0·1096	0·0685	0·0822	....	0·1370	0·3973

Colour. The female resembles the male in colour and general appearance. Hence, only the following characters need be described:—

Eyes. The eight eyes are arranged in two rows. The anterior row viewed from above appears very slightly recurved; viewed from in front, it is distinctly procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is procurved. Ratio of eyes AME : ALE : PME : PLE = 4 : 4 : 7 (long) : 4. The width of the eye-group is slightly less than the width of the carapace in the region of the eyes. AME are separated from each other by a space equal to their diameter and from PME by about half this distance. They are in contact with ALE, which are in contact with PLE. PME are large, flat, and reniform. They are contiguous with each other but separated from PLE by a space equal to half the diameter of AME. The quadrangle formed by the median eyes is wider in front than behind in ratio 9 : 8. Its length is greater than its anterior width in ratio 14 : 9. AME are dark, the other eyes pearly white. The height of the clypeus in front of AME is about 9/4 times the diameter of AME.

Chelicerae, Maxillae, Labium, and *Sternum.* As in the male.

Legs. 4.1.2.3. In form, clothing, and arrangement of the trichobothria the legs resemble those of the male. However, they are somewhat shorter, except in the case of the fourth pair, and there is a slight difference in the pectination of the claws on the third and fourth tarsi, as indicated in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	10	1	9	1
Leg 2	9	1	8	1
Leg 3	8	1	1	6
Leg 4	6	0	0	5

Palpi. Lightly clothed with barbed setae. A single trichobothrium is present near the middle of the tibia. The tarsal claw is curved and expanded so that the promarginal teeth form a row, which is almost transverse to the long axis of the tarsus. The claw is carried on a short onychium and has eight teeth on the promargin and one on the retromargin (pl. III, fig. 25).

Abdomen. The dorsal surface is covered by a hard oval shield resembling that of the male. There is a small V-shaped median notch in the anterior margin, and on each side of the notch a number of coarse setae. The rest of the shield is clothed with small hairs. The ventral surface is provided with a ring-like sclerite surrounding the base of the pedicle. Behind this is a median shield, on which the epigynum is situated. On each side of this median shield, but separated from it is an elongate pulmonary sclerite covering the book-lung. The lung-slit is situated between the posterior end of the pulmonary sclerite and a smaller sclerite immediately behind it. Posterior to the epigynum is a small triangular scute, on each side of which are two small sclerites, one behind the other. The posterior half of the ventral surface of the abdomen is covered by a large rectangular scute, behind which is a transverse row of three small sclerites. The median sclerite of the row is immediately in front of the spinnerets and bears the tracheal spiracle (pl. III, fig. 26). The sides of the abdomen have a series of longitudinal folds as in the male.

Spinnerets. Six. The anterior pair and posterior pair two-segmented, the apical segment small and conical. The posterior pair slightly smaller than the anterior pair. The middle spinnerets are very small and usually hidden by the others. On the inner surface of the basal segment of each anterior spinneret the chitin is thickened and provided with fine transverse ridges forming a stridulating organ as in the male (pl. III, fig. 27).

Epigynum. The form of the epigynum in surface view is shown in pl. III, fig. 28, and in transparent preparations in pl. V, fig. 40. In surface view it appears as a somewhat triangular depression, from the apex of which there projects backward a short scape or ovipositor. The spermathecae are visible through the integument as two dark circular areas, one on each side of the scape.

Habits. Specimens kept in the laboratory did not spin a web or make any nest. A male and female were observed in copulation on 24th August, 1934. The position adopted is shown in pl. IV, fig. 29. Unfortunately the female died without making an egg-sac. The spider is usually found during the months May to September. It occurs in grass-tussocks, moss, and lichens.

Localities. The type-specimen (♂) was collected at Fingal and the ♀ on the Domain, Hobart. Co-types were found at Trevallyn, Launceston. My collection also contains a male, found by Mr. C. Oke in Victoria.

Hadrotarsus setosus, sp. n.

Male. Measurements in millimetres:—

Total length	1·4385
Length of cephalothorax	0·5891
Width of cephalothorax	0·5343
Length of abdomen	1·1097
Width of abdomen	0·7535

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0·4110	0·2329	0·3288	0·1781	0·3288	1·4796
2	0·4110	0·2055	0·2740	0·1781	0·2877	1·3563
3	0·3699	0·2055	0·2740	0·1644	0·2877	1·3015
4	0·4795	0·2740	0·3562	0·2466	0·3562	1·7125
Palp	0·3151	0·1096	0·0685	....	0·3425	0·8357

Colour. Light chestnut brown without markings. Ocular area black anteriorly Two large muscle spots near middle of dorsal surface of abdomen.

Carapace. Slightly longer than wide. Clothed with a few small scattered hairs. Thoracic groove wanting. Sides well rounded. Front somewhat narrowed (pl. IV, fig. 30).

Eyes. The eye-group occupies almost the whole width of the carapace in the region of the eyes. The eight eyes are arranged in two rows. Viewed from above the front row is slightly recurved, but viewed from in front it is strongly procurved, ALE being nearer the edge of the clypeus than are AME. The posterior row is procurved. AME dark, the other eyes pearly white. Posterior median eyes large, flat, and reniform (pl. IV, fig. 31). Ratio of eyes AME : ALE : PME : PLE = 4 : 4 : 6 (long) : 4. AME separated from each other by $\frac{3}{4}$ of their diameter and from PME by slightly more than $\frac{1}{4}$ of their diameter. AME are in contact with ALE, which are in contact with PLE. The PME are almost in contact with each other but are separated from PLE by $\frac{1}{2}$ the diameter of AME. The quadrangle formed by the median eyes wider in front than behind in ratio 9 : 8. Its length is greater than its anterior width in ratio 10 : 9. The height of the clypeus in front of AME is equal to nearly three times the diameter of AME.

Chelicerae. Very small, conical, and lacking teeth, scopula and lateral condyles. Fangs long, sharp, and falcate.

Maxillae. Triangular, converging in front of labium. Apex pointed, membranous, and pellucid. A serrula consisting of a row of about ten teeth is situated on the antero-lateral margin.

Labium. Triangular with rounded apex. Nearly twice as wide as long.

Sternum. Convex, rounded and triangular. Longer than wide in ratio 27 : 24. Posterior end truncated. Fourth coxae well separated. Middle of sternum smooth and glabrous, the sub-marginal region with a few setae which point inwards (pl. IV, fig. 32).

Legs. 4.1.2.3. Tarsi of first pair distinctly swollen. Metatarsi much shorter than tarsi. Two trichobothria on each tibia and one near the apex of each metatarsus. Clothing of legs consists of barbed hairs, but spines, scopulae, and claw-tufts are absent. Two tarsal claws situated on an onychium are present. The onychium also carries a pair of barbed setae resembling spurious claws. The pectination of the true claws resembles that of the preceding species. The following table gives the number of teeth on each claw:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	9	1	7	1
Leg 2	7	1	7	1
Leg 3	6	1	1	5
Leg 4	5	0	0	5

Palpi. The form of the right palpus is shown in pl. IV, figs 33 and 34. The tibia is very short and saucer-shaped. It carries a single trichobothrium. The cymbium is large and spoon-shaped with the alveolus more or less on the retro-lateral side. The embolus is long and thread-like. It makes about three complete circular turns on the side of the genital bulb. In the single specimen examined the free end of the embolus projected beyond the cymbium and then curved back as shown in the figure. It is probable, however, that the end had become dislodged from the normal resting position. No apophysis is present on the tibia or tarsus.

Abdomen. The dorsal surface is covered by a hard shield which has a small median V-shaped notch on its front margin. On each side of the notch are several setae which are longer and more slender than those of the two preceding species. Moreover, the hairs which cover the rest of the dorsal shield are coarser than in the case of either *H. fulvus* or *H. ornatus*. There are two conspicuous muscle spots near the middle of the scute. The anterior half of the ventral surface is covered by a large epigastric scute, which extends forward and surrounds the pedicle (pl. IV, fig. 32). Behind the large scute is a transverse row of three small scutes, the middle one of which is smaller than the lateral ones. The latter are fused to the posterior angles of the large epigastric scute leaving, on each side, a narrow transverse notch, which opens towards the middle. In the two notches thus formed the openings of the two book-lungs are situated. The posterior half of the ventral surface of the abdomen is mainly covered by a large ventral scute. Situated near the antero-lateral angles of the ventral scute are two small sclerites, one on each side. Immediately in front of the spinnerets and partly hidden by the posterior margin of the large ventral scute is a small sclerite, on which is situated the tracheal spiracle. The integument between the dorsal and ventral surfaces of the abdomen forms three longitudinal folds, two of which appear to be continuous above the pedicle in front and the anal tubercle behind.

Spinnerets. Six. There is a small sclerite on each side of the spinnerets, but the group is not surrounded by a chitinous ring. Each spinneret, however, has a hard investment of chitin. The anterior pair consist of a large basal segment and a small conical apical segment. The inner surface of the basal segment is thickened and marked with stridulating ridges as in the two preceding species. The posterior spinnerets are slightly smaller than the anterior pair. They are two-segmented, the apical segment being very small and sunken in the end of the basal segment. The middle spinnerets are very small and almost hidden by the others.

Locality. Victoria. A single male specimen collected by Mr. C. Oke.

Notes on the Internal Anatomy.

The following notes refer to the main features of the internal anatomy of *H. ornatus* and *H. fulvus*. Specimens were fixed in Carnoy's Fluid and studied in serial sections stained with haematoxylin and eosin. As only one specimen of *H. setosus* was available, no attempt was made to examine its internal structure.

Abdominal Musculature. The musculature of the abdomen is much reduced. There is a pair of latero-cardiac muscles, which arise from the dorsal shield and pass obliquely downwards, one on each side of the heart, and close to the second pair of ostia. They are inserted in the posterior end of the lorum of the pedicle (pl. V. fig. 35). Some distance behind the latero-cardiac muscles is a pair of strong dorso-ventral muscles, which arise from the two conspicuous muscle spots near the middle of the dorsal shield and pass downwards to be inserted in two pairs of

median endosternites. These are close together and above the epigastric furrow. They probably represent the endosternites of the 8th and 9th body-segments (i.e., the 2nd and 3rd segments of the abdomen). Hence the dorso-ventral muscle bands, which appear single, are probably composed of the dorso-ventral muscles of the two segments. Connecting the margin of the dorsal shield with the ventral sclerites are numerous short dorso-ventral muscles which do not appear to have any segmental arrangement. In addition to the muscles mentioned, there are two pairs of dorso-ventral muscles in the pedicle and a series of longitudinal ventral muscles, as shown in pl. V, fig. 35.

Digestive System. The thoracenteron is of the classic type. It consists of four pairs of caeca extending outwards and downwards to the coxae of the four pairs of legs.

The primary branching of the chylenteron gives rise to a single midventral diverticulum, two pairs of lateral diverticula and one pair of dorsal diverticula. The midventral diverticulum and the first pair of lateral diverticula arise close together from the main tube a short distance behind the pedicle. Farther back the second pair of lateral diverticula are given off and posterior to these the dorsal diverticula arise.

Each maxilla contains a single oblong multi-cellular gland, which is about two-thirds the length of the endite. It has a large lumen which acts as a reservoir. The ducts of the gland are not clearly visible, but they appear to open on the inner margin of the maxilla near the base of the scopula. A rostral gland is also present. It is rounded without any appearance of being bilobed. It opens into a wide transverse slit-like aperture on the front of the rostrum near the apex (pl. V, fig. 38).

Excretory System. The usual pair of biramous malpighian tubules are present. They open into the gut just in front of the stercoral pouch. No trace of coxal glands in the cephalothorax could be found.

Poison Glands. These glands are endocephalic. They are fusiform in shape and situated in an almost vertical position. In *H. ornatus* they extend from immediately below the posterior median eyes into the base of the chelicerae. In *H. fulvus* the glands are similar in shape, but smaller.

Silk Glands. In the females of both *H. ornatus* and *H. fulvus* two very large pear-shaped glands are situated below the stercoral pouch (pl. V, fig. 36). They extend forward as far as the ovary. Posteriorly they open by the large spigot on the hind spinnerets.

Six cylindrical glands are also present. These are situated, three on each side, one above the other and close to the large pear-shaped glands. They extend forward nearly to the front of the ovary and their anterior ends are somewhat bent or twisted. Of the three glands on each side the uppermost one opens on the corresponding middle spinneret, the other two on the inner side of the posterior spinneret. In the males these cylindrical glands appear to be absent. The wall of the glands is very thick and stains deeply.

The anterior spinnerets are supplied with silk from a large number of small pyriform glands arranged in two groups, one on each side and close to the basal segments of the spinnerets.

Reproductive System. The appearance of the vaginal system of *H. ornatus* and *H. fulvus*, as seen in transparent preparations, is shown in pl. V, figs 39 and 40. In both species the afferent ducts leading to the spermathecae are very long. In

H. ornatus they are coiled so as to form a narrow spiral surrounded by a wider spiral. In *H. fulvus* the ducts are not coiled, but form several loops which extend laterally as far as the book-lungs. In both species the spermathecae are large and rounded. In *H. fulvus* each is connected with a spermathecal gland situated towards the front of the vaginal system.

In the males the vasa deferentia open into a large spherical vesicula seminalis situated near the genital aperture.

Circulatory System. The heart is fusiform and curved dorso-ventrally. It has two pairs of ostia (pl. V, fig. 37). The anterior pair are the larger and are situated in a dorso-lateral position at the front of the heart. The second pair are smaller and also dorso-lateral in position. The descending latero-cardiac muscles pass close to them. The interval between the first and second pair of ostia is slightly less than that between the second pair and the posterior end of the heart.

Respiratory System. The organs of respiration consist of a single pair of book-lungs and a system of tracheal tubes. The book-lungs occupy the normal position, one on each side, in front of the epigastric furrow. In *H. ornatus* each book-lung has eleven leaves and in *H. fulvus* nine. The tracheal system is confined to the abdomen and is composed of four simple tubes, which unite in a short atrium before opening on the exterior by the single median spiracle in front of the spinnerets. Two of the tubes are short and run straight forward parallel with the longitudinal ventral muscles to end near the epigastric furrow. The other two tubes pass outwards and run obliquely forwards converging on the heart. They pass through the wall of the pericardium in front of the latero-cardiac muscles and enter the pericardial cavity, where they lie, one on each side of the heart. They end near the front of the heart.

New Definition of the Family Hadrotarsidae

Dipneumone, quadrostiate spiders. Carapace without thoracic groove. Eight eyes in two rows. Posterior median eyes large, flat, and reniform. Chelicerae without teeth and lateral condyles. Poison glands endocephalic. Fang falcate. Maxillary lobes strongly converging and provided with a serrula. Sternum triangular and rounded with truncated posterior end separating the fourth coxae. Lip free, wider than long. Tarsal segments of first pair of legs swollen. Metatarsi much shorter than tarsi. Trochanters without notch. Two trichobothria on each tibia and one on each metatarsus. Legs lacking spines, scopulae and claw-tufts. Two tarsal claws situated on an onychium. The claws of the first three pairs of legs pectinate in a double row, those of the fourth pair in a single row. Dorsal surface of abdomen covered with a hard shield, ventral surface with an epigastric scute, a ventral scute and several smaller sclerites. In the males the epigastric scute surrounds the pedicle. The two pulmonary spiracles situated one on each side in the epigastric furrow. The single median tracheal spiracle immediately in front of the spinnerets leads into a short atrium which gives rise to four tracheal tubes, which are confined to the abdomen. Six spinnerets. Anterior spinnerets contiguous, two-segmented and with transverse stridulating ridges on the inner surface of the basal segment. Median spinnerets small, contiguous and composed of one segment. Posterior spinnerets two-segmented and slightly shorter than anterior pair. Integument with barbed hair. Genital bulb of male provided with a long thread-like embolus. Epigynum of female complex.

The family Hadrotarsidae as defined above includes the four species of the genus *Hadrotarsus*. The position of *Gmogala scarabaea* Keyserling must remain uncertain until the type specimen is again examined and described in greater detail. However, it has so many features in common with species belonging to the genus *Hadrotarsus* that it might be expected to have a similar respiratory system. Pocock's description of the tracheal spiracles as a 'pair of contiguous round dark spots, surrounded by a circular rim' might apply equally well to a small sclerite with a pair of round dark spots representing the small cup-like depressions from which a pair of setae had been rubbed off or removed. While Pocock corrected some of the errors made by Keyserling in the original description of *G. scarabaea*, he has left students in doubt with regard to several important features of the external anatomy.

Acknowledgments are made to the Trustees of the John Ralston Bequest, under whose auspices the above work was carried out.

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PLATE I.

Hadrotarsus ornatus, sp. n.

Fig. 1.—Dorsal view of male. Legs of left side omitted.
Fig. 2.—Eyes of male viewed from above.
Fig. 3.—Right chelicera of male viewed from the front.
Fig. 4.—Maxillae and labium of male.
Fig. 5.—Leg of first pair showing swollen tarus and the position of the trichobothria on the tibia and metatarsus.
Fig. 6.—Leg of second pair showing position of the trichobothria.
Fig. 7.—Ventral view of tarsal claws of first leg of male.
Fig. 8.—Ventral view of tarsal claws of third leg of male.
Fig. 9.—Ventral view of tarsal claws of fourth leg of male.
Fig. 10.—Left palpus of male showing genital bulb and the coiled embolus.
Fig. 11.—Terminal apophysis of genital bulb.
Fig. 12.—End of embolus showing barb near the tip.

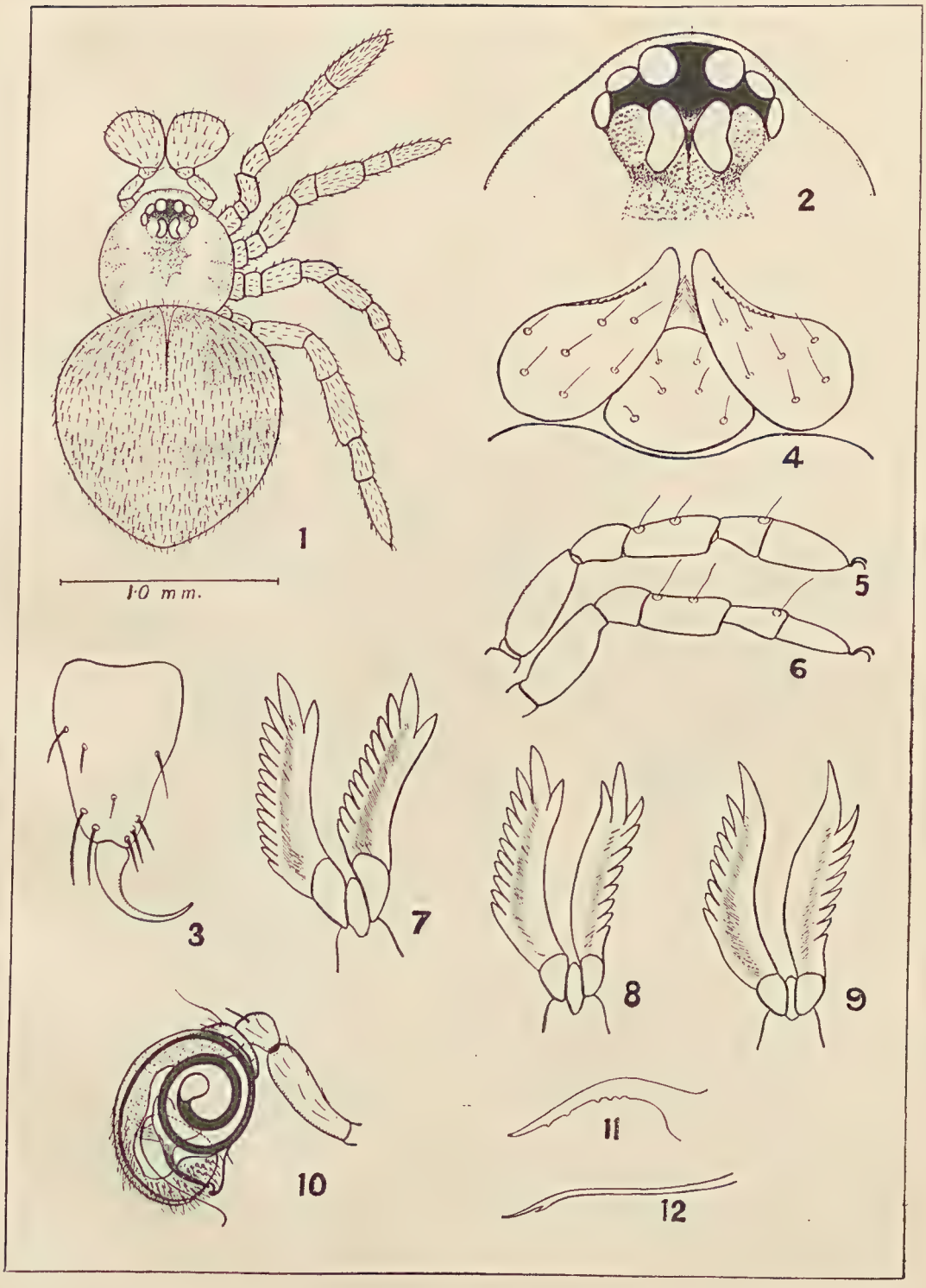
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PLATE II.

Hadrotarsus ornatus, sp. n.

FIG. 13.—Ventral view of sternum and abdomen of male.
FIG. 14.—Anterior spinnerets of male showing the tranverse ridges probably used in stridulating.
FIG. 15.—A posterior spinneret of male showing the large spigot.
FIG. 16.—A middle spinneret of male.
FIG. 17.—Ventral view of tarsal claw of left palpus of female. *p.t.*, promarginal teeth; *r.t.*, retromarginal tooth.
FIG. 18.—Ventral view of sternum and abdomen of female.
FIG. 19.—Epigynum in surface view.

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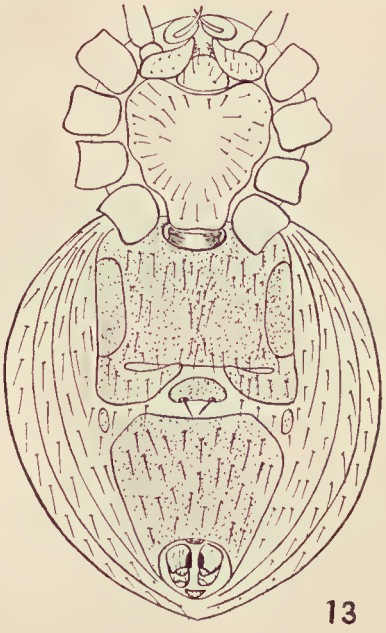

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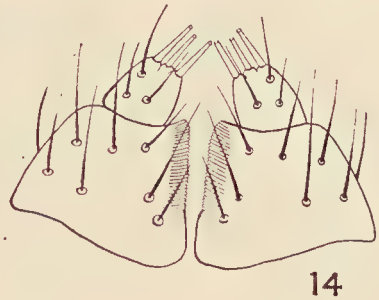

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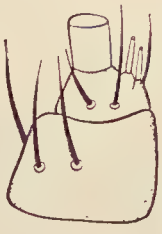

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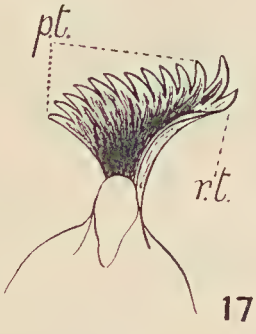

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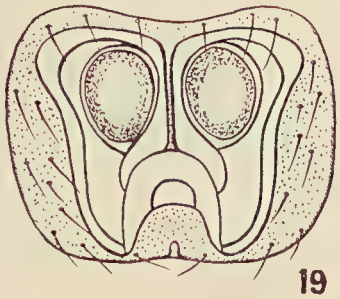

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PLATE III.

Hadrotarsus fulvus, sp. n.

FIG. 20.—Dorsal view of male. Legs of left side omitted.
FIG. 21.—Retrolateral view of right palpus of male.
FIG. 22.—Prolateral view of right palpus of male.
FIG. 23.—Right chelicera of male viewed from the front.
FIG. 24.—Ventral view of sternum and abdomen of male. *p.s.*, position of pulmonary spiracle; *t.s.*, tracheal spiracle.
FIG. 25.—Ventral view of tarsal claw of right palpus of female.
FIG. 26.—Ventral view of sternum and abdomen of female.
FIG. 27.—Anterior spinnerets of female showing the transverse stridulating ridges. *t.s.*, tracheal spiracle on small sclerite in front of spinnerets.
FIG. 28.—Epigynum in surface view.

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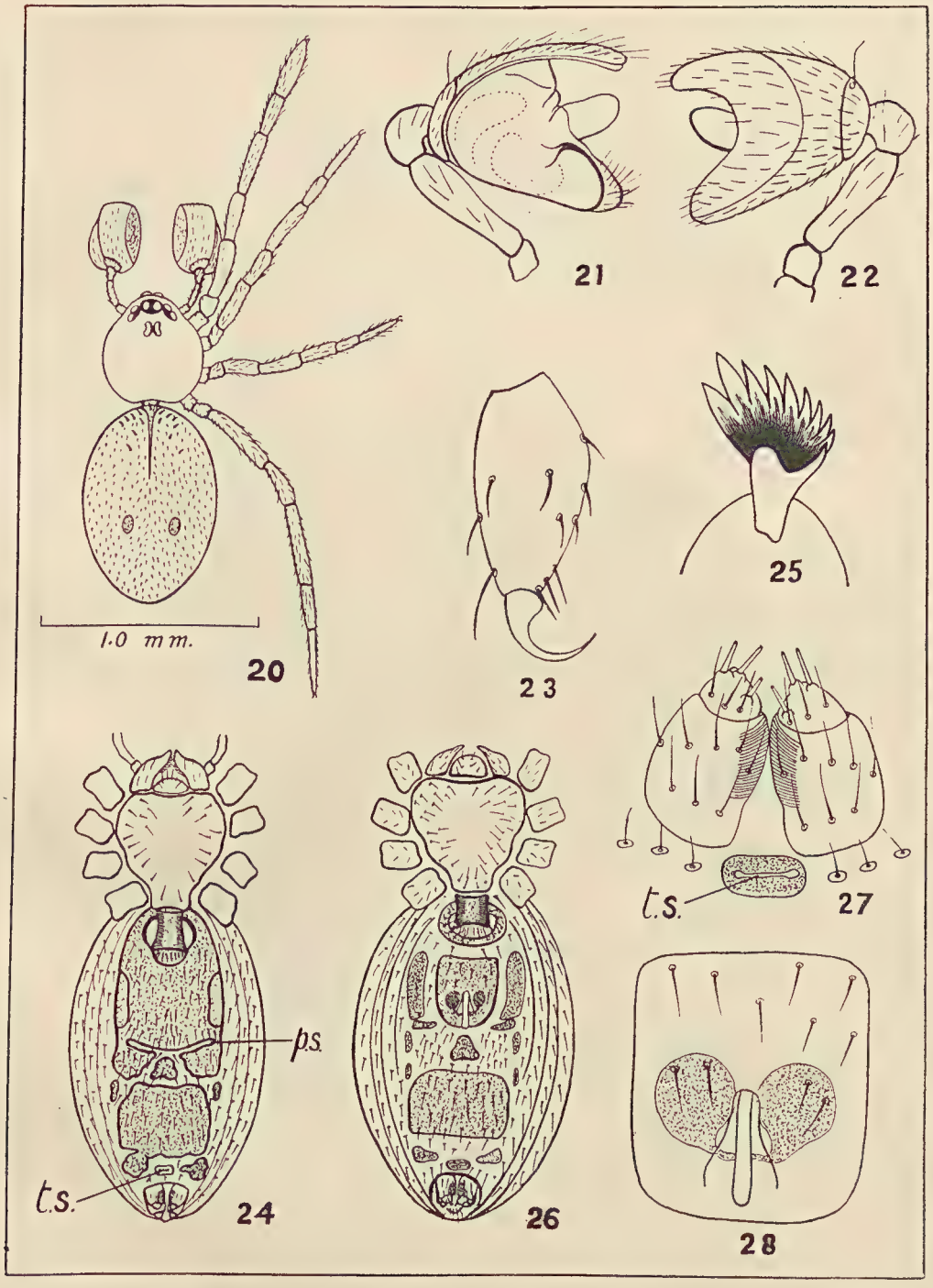
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PLATE IV.

Hadrotarsus fulvus, sp. n.

FIG. 29.—Lateral view of male and female in copulation.

Hadrotarsus setosus, sp. n.

FIG. 30.—Dorsal view of male. Legs and palpi omitted.
FIG. 31.—Eyes of male viewed from above.
FIG. 32.—Ventral view of sternum and abdomen of male.
FIG. 33.—Retrolateral view of right palpus of male showing coiled embolus.
FIG. 34.—Prolateral view of right palpus of male.

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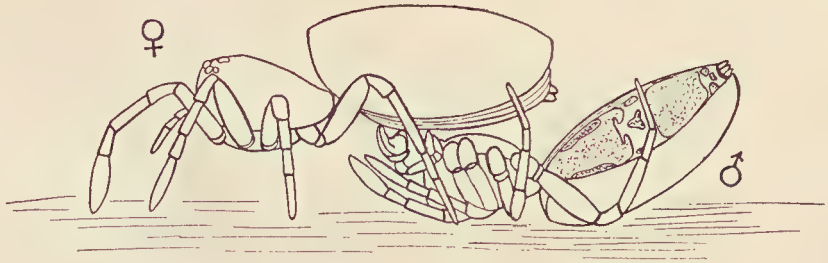

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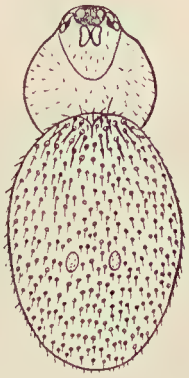

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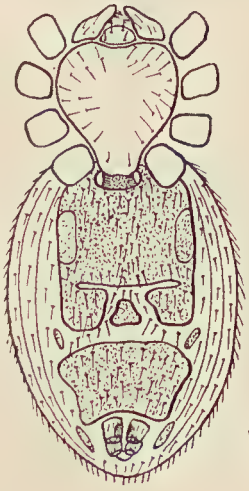

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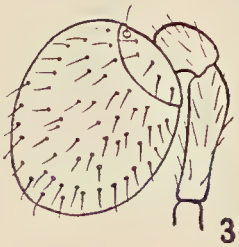

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PLATE V.

Hadrotarsus ornatus sp. n.

FIG. 35.—Muscles of abdomen. *d.v.* VIII and IX, dorso-ventral muscles of body segments VIII and IX; *lc.*, latero-cardiac muscle; *ml.* VIII, IX, and X, median longitudinal muscles of body segments VIII, IX, and X; *s.p.*, stercoral pouch.

FIG. 36.—Transverse section of abdomen of female passing through the front of the stercoral pouch. *c.g.*, cylindrical silk-glands; *d.d.* dorsal diverticula of gut; *l.t.*, lateral tracheal tube; *s.g.*, large pear-shaped silk gland; *v.d.*, midventral diverticulum of gut; *v.t.*, ventral tracheal tubes.

FIG. 37.—Dorsal view of heart showing the position of the four ostia. *lc.*, latero-cardiac muscle.

FIG. 38.—Frontal section through rostrum showing the rostral gland. *ap.*, slit-like aperture of gland.

FIG. 39.—Epigynum as seen in transparent preparations.

Hadrotarsus fulvus, sp. n.

FIG. 40.—Epigynum as seen in transparent preparations.

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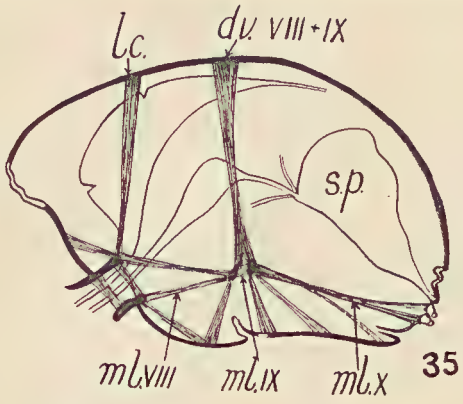

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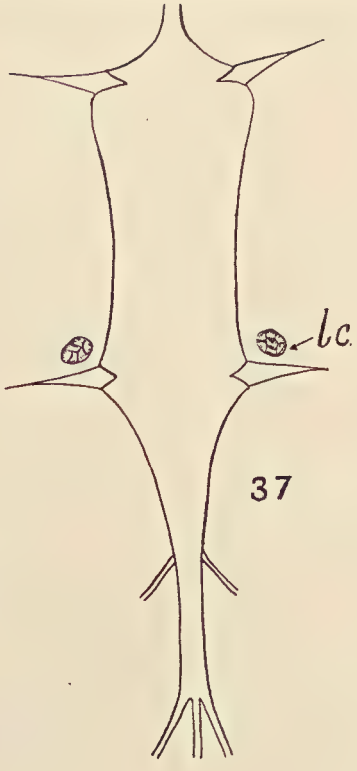

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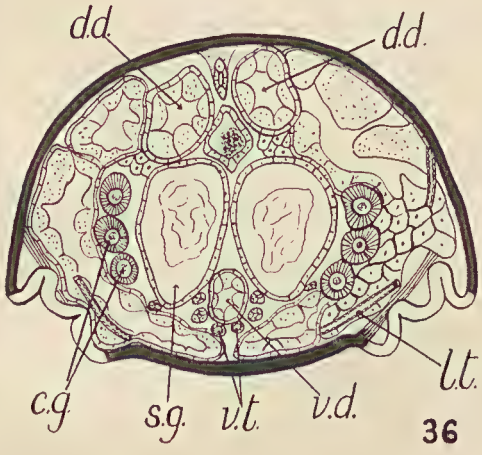

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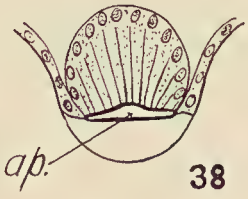

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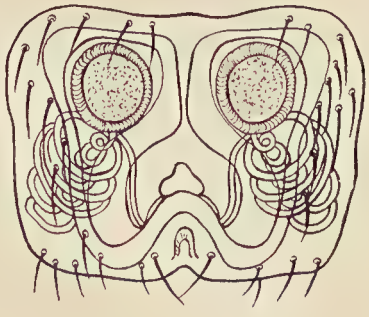

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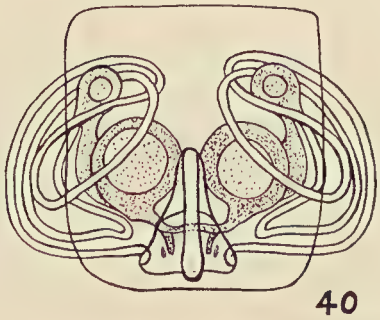

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1942

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Annual Report, 1942

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 9th March, 1942.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules, Mr. E. E. Unwin retired from the office of Vice-President, and Mr. A. L. Meston was appointed in his place (retiring 1944).

Treasurer: Mr. S. Angel.

Council: Under the Rules, Dr. A. N. Lewis and Dr. V. V. Hickman retired from the Council, and the following members were elected to the Council in their place:—

Mr. N. P. Booth (retiring 1945).

Dr. H. D. Gordon (retiring 1945).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens:— Mr. W. H. Clemes and Mr. E. E. Unwin.

Nine meetings were held during the year (see proceedings for abstracts of papers). In addition, scientific papers were submitted for publication and have been printed in the present volume.

Library

It was agreed, on the recommendation of the Council, to make the following changes in the hours of opening the Society's Library:—

Mondays: 10 a.m. to 1 p.m. and 2 p.m. to 5 p.m.

Wednesdays and Fridays: 10 a.m. to 1 p.m.

Also at 7.30 to 8 p.m. on the evenings when a General Meeting is held.

During the year 138 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign institutions and learned societies. The number of institutions on the Exchange List for the year was 270, being made up of 124 British, 54 American, and 92 from other parts of the world. No foreign exchanges have been sent since the 1938 volume, and subsequent issues are being held until the conclusion of the war. This year it was felt advisable also to withhold British and American exchanges. The Library now consists of 20,264 volumes.

The sum of £22 16s. 9d. was spent on books during the year, and the account allocated as follows:—

	£	s.	d.
General Fund	1	4	2
R. M. Johnston Fund	9	11	3
Morton Allport Memorial Fund	6	14	0
Beattie Memorial Fund	5	7	4

In addition, the Tasmanian Museum spent £4 1s. 3d. on books, which have been placed in the Society's Library for safekeeping, and are available to members.

Membership

The Society consists of the following members:—

	1941.	1942.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	6
Ordinary Members	210	213
Associate Members	5	4
	227	228

During the year 14 names were removed from the list of Ordinary Members owing to deaths, resignations, etc., and 17 new members were elected.

Also, the resignation of one Associate Member was received, and one Associate Member was transferred to Ordinary Membership, while one new Associate Member was elected.

The Council regrets having to record the deaths of the following members during the year:—Dr. Gregory Sprott, Mrs. S. H. Hancox, Mr. F. J. Heyward.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

Abstract of Proceedings

9th March, 1942

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1942:—Mr. A. L. Meston was elected Vice-President in the place of Mr. E. E. Unwin, who retired under Rule 12; Mr. N. P. Booth and Dr. H. D. Gordon were elected in the places of Dr. A. N. Lewis and Dr. V. V. Hickman, who retired under Rule 21; Treasurer, Mr. S. Angel.

Mr. H. J. Exley was appointed Hon. Auditor.

Mr. T. A. Gepp was elected a member of the Society.

Dr. W. L. Crowther read a paper entitled 'The Life of Dr. Fordyce Storey in Tasmania, 1829-1885', which was prepared by Mrs. J. A. McElroy.

13th April, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The following were elected members of the Society:—Mrs. E. A. Charles, Miss L. van Gooch, Mr. J. C. Bennett, Mr. M. Bennett, Mr. F. C. Wolfhagen.

Mr. E. E. Unwin delivered an illustrated lecture entitled 'The Voices of Animals', of which the following is an abstract:—

> An inquiry into the purposeful sounds produced by animals as a means of communication, illustrated by slides and pictures, as well as gramophone recordings of animal voices. Some attempt was made to describe the sound recording apparatus as well as the sound producing—for hearing sounds is as important as making them.
>
> The lecture covered the following aspects:—
>
> Tapping sounds.—Spiders, Booklice, Deathwatch, Beetles, Termites.
> Buzzing sounds.—Blowfly, Mosquito, Bees, and Wasps.
> Stridulating sounds.—Beetles, Waterboatmen, Moths, Ants, Locusts and Grasshoppers, Crickets, Cicada.
> Sounds made by fishes.
> Vocal cords and air.—*(a)* Frogs and Reptiles; *(b)* Birds (syrinx); *(c)* Mammals (larynx).
> Reasons for sound producing.
> The development of a language of words in man.

11th May, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Ordinary Members, Mrs. C. H. C. Hebblethwaite, Mr. C. H. C. Hebblethwaite; Associate Member, Mr. P. Crowcroft.

Mr. W. T. Dowsett delivered a lecture entitled 'Social Services and their importance in War-time and Post-war Period', of which the following is an abstract:—

1. *The Nature and Purpose of Social Services.*

To indicate the effects that a state of war may reasonably be expected to produce upon the social services, and to suggest any desirable developments in them after the war, the purpose of social services must be realised. Examination of the type of services given in such classifications as the Drage Return (1921) and the Political and Economic Planning Report (1937) indicates that their object is 'the enhancement of the personal welfare of individual citizens of the community'. History shows that the motives behind their inauguration all accepted the existing social and economic system without intention to change it. Furthermore, while in the nineteenth century the growth of the services was haphazard, in this generation the aims of consistent application and unified purpose are appearing.

Social services may thus be defined as that unified body of services, undertaken or supervised by the State, which accepts the existing social and economic system without seeking merely to preserve it or, alternatively, to change it, but which for motives of social or economic efficiency, endeavours to assure to each individual or family unit all those requirements of a reasonable living standard that the system may otherwise fail to provide. In a community with an arbitration system aiming to secure for each employed worker what is conventionally called a living wage, the following would be the chief fields of such social service structure:—*(a)* employment (including exchanges, re-training agencies, and employment insurance); *(b)* health (involving hospitals and public medical services, inspection and health insurance); *(c)* full education (including with schools and universities such institutions as playgrounds, museums and state theatres); *(d)* old-age and invalid pensions, provided as far as possible on the insurance principle.

2. *Social Services in War-time.*

Since social services accept the system, their pattern must be changed to recognise the conditions of total war. Three conditions are involved:—since war means community sacrifice the general level of the services must fall; but, since the change in the economic pattern impinges disproportionately upon different groups, certain specific services will need actual extension; and some services may expand as part of the war organisation of the community.

Two factors will produce the changes:—increased man-power needs, and curtailed customer demand. The former will stimulate the employment function, developing new machinery for transfer across industries. It will expand physical education and vocational training, but depress other educational services generally. Other services will expand to meet the needs of dependents of men in the forces, but will otherwise tend to contract.

The curtailing of consumer demand will call for some extension of relief services, for the burden of the war will bring increasing numbers in low income groups nearer the breaking point. Moreover, food deficiency, overstrain, and the risk of epidemic will tend to extend the public health function.

3. *Social Services after the War.*

The post-war period will be concerned with the transfer of industry from war to peace, and industrial adjustment to the emerging new international trade conditions. Thus, while there will be a call to restore services contracted in war-time, the chief extensions will occur where increased employment is involved. Re-training agencies will be strengthened. Education should be extended to find new administrators, to meet possible enforced leisure, and to stimulate the movements towards more tertiary employment. New hospitals will provide employment for builders and doctors. Playgrounds, beside involving construction, will find openings for trained supervisors.

When a degree of equilibrium is reached, welfare should become the chief objective. This will necessitate an all-round extension of social services, but the most important problem will then be the devising of administrative machinery capable of producing the ideal unified body of services that we have failed so far to obtain. Since all these tasks are urgent, the great need is for immediate research and planning. The blue-prints should be ready before the war ends, for only immediate application can prevent disaster.

8TH JUNE, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

Mr. E. T. Emmett delivered an illustrated lecture entitled 'Frenchman's Cap', of which the following is an abstract:—

It is not known who named Frenchman's Cap. The mountain is mentioned by Jorgensen in his explorations of 1827, and the name appears on maps of 1830. Surveyor-General Sharland climbed portion of the mountain in 1832. The cairn was erected during Surveyor-General Sprent's surveys, about 1850. On a small piece of wood near the cairn are carved the names of Tully, Glover, and Spong, who ascended the Cap in 1859. A track was cut to the summit in 1910 by J. E. Philp by way of the Barron Pass, but this became overgrown. It has been re-opened, and this is the route now followed, starting by the Jane River track from the Hobart-Queenstown road, turning off at a point in the Loddon Plains, where Philp's direction board still remains. The distance is not much more than twelve miles from the Queenstown highway to the summit, but the country is extremely rough and it is a good two-day journey. The scenery is highly spectacular, with a sheer wall of white quartzite rising for nearly 1500 ft. from Lake Tahune. On the route are forests of extraordinary beauty. The lecturer suggested that it would be profitable after the War to have the track made easier and two or three camping huts provided, for the magnificence of the area would attract quite a large traffic. About 38 square miles round Frenchman's Cap has been proclaimed a National Park.

13TH JULY, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Miss B. B. Adams, Mr. H. J. King, Mr. Roy Smith.

The Secretary announced that Mr. C. E. Radcliff had presented a copy of the two-volume work of Erasmus Darwin 'Zoonomia' to the Society's Library, and the books were laid on the table for the inspection of members.

Photographs of old Hobart were also displayed on the table. These were taken by Mr. W. H. Craig, Architect, of Melbourne.

Mr. G. P. Whitley, Ichthyologist of the Australian Museum, Sydney, delivered an illustrated lecture entitled 'Sharks', of which the following is an abstract:—

Mr. Whitley began by dispelling some popular delusions. Most sharks, far from being ferocious man-eaters, were harmless fish-eating animals. It was not necessary for them to turn over on their backs to take their food, neither did they always show the dorsal fin above water. Both white and coloured persons have been attacked by man-eaters. No authentic case of shark attack in Tasmanian waters was known to the lecturer.

Recently, a shark fishery had sprung into prominence in Victoria, where sharks were required for food and as a source of oil; they also yielded leather and fertilizer. The fishing methods and disposal of the catch were described. The need for biological research on sharks was stressed so that depletion of a valuable industry could be guarded against. Correct classification of the species was of prime importance, followed by a stabilising of the vernacular names. Investigations into the numbers and sizes of sharks caught, their growth, food, sex-ratio, and breeding habits were discussed. Sharks had recently been marked and liberated for the first time in Australia, in the d'Entrecasteaux Channel, by means of celluloid tags inserted in their bodies. It was hoped that the tags would be recovered by persons cleaning the sharks when recaught and thus data on migration and growth would be secured.

24TH AUGUST, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The Secretary intimated that, until further notice, the Library hours would be as follows:—

Mondays: 10 a.m. to 1 p.m. and 2 p.m. to 5 p.m.

Wednesdays and Fridays: 10 a.m. to 1 p.m.

Also at 7.30 to 8 p.m. on the evenings when a General Meeting is held.

The Secretary tabled a paper entitled 'The Phreatoicoidea', by Professor G. E. Nicholls, which had been submitted for publication in the Society's Journal. It was agreed to submit this to the Standing Committee.

Dr. J. B. G. Muir delivered an illustrated lecture entitled 'The present position in North China and Manchukuo'.

21st September, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mrs. N. I. Stewart, Dr. E. T. J. Ick.

Dr. J. C. Jaeger delivered an illustrated lecture entitled 'Charcoal, its Properties and Production', of which the following is an abstract:—

> A discussion of the properties of charcoal and of their effects on its performance in gas producers was given. In this work charcoal is regarded as being composed of volatile matter, ash, and carbon. The volatile matter consists of combustible gas, together with a small proportion of condensible vapour or tar. A high percentage of volatile matter is desirable, provided excess tar is not present; charcoal of over 25 per cent volatile content usually contains too high a concentration of tar, and that from partially carbonized wood almost certainly does so. Charcoal of high ash content also is undesirable, but no Tasmanian timbers have been found to give an abnormally high ash content. Bark, however, has a high ash content and thus must be removed before carbonizing.
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> The quality of charcoal is greatly influenced by the rate at which the wood is heated during the burning process; if the heating is rapid a friable, low volatile charcoal is produced, while slow heating gives a hard, high volatile charcoal. Large pieces of wood may heat rapidly in their interior because of the heat given out by the wood when carbonizing, and thus the charcoal from large pieces of wood may be inferior to that from small. Charcoal made from green wood has a flakey structure, except in the outer layers, due to the shrinking of the wood when drying.
>
> The requirements of a satisfactory process of charcoal burning are firstly that there be an adequate control of the draught, and secondly that the draught should not pass through burnt charcoal. Charcoal is normally burnt in open or closed pits, or in kilns. The open pit method is not very satisfactory as there is little control over the draught and the burning is very hot, giving a light, soft, low volatile charcoal. The reverse draught closed pit has a simple but adequate draught control and should be capable of producing almost as good charcoal as steel kilns; in the latter very careful regulation of the draught is possible. The latest advance is the Kurth kiln which provides a continuous process, wood being fed in at the top and charcoal removed from the bottom; the recovery of valuable by-products is possible with this kiln.

26th October, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The following were elected members of the Society:—Mrs. O. Cornell, Mr. W. Baulch, Mr. E. A. Elms.

Mr. A. L. Meston delivered a lecture entitled 'Place Names in Tasmania'.

Miss Travers lent her copy of the illustrations to Péron's Voyages. This was laid on the table, and was examined by members after the meeting. These maps gave some of the old French names.

The following is an abstract of the lecture by Mr. Meston:—

> Place names may be classified into three groups. First there are those given in honour of some person, place, or event; secondly those given to commemorate some incident; and thirdly those descriptive of the physical features they name.

Tasman's Frederick Henry Bay and Maria Island, Hayes' Ralph's Bay and the River Derwent, Flinders' Waterhouse Island, Point Hibbs, Mts. Zeehan and Heemskirk are examples of the first group; Storm Bay, Bay of Fires of the second group; and the great number of names bestowed along our northern coast by Flinders in 1798, such as Low Head, Round Hill, Table Cape, Rocky Cape, Circular Head, Cape Grim of the third group.

Many Tasmanian place names have wandered from their original location. Two prominent examples are Frederick Henry Bay, which by an error of Furneaux was transferred from a bay on the east coast to a bay near the mouth of the Derwent, and the Eldon Range, which has been applied to a range much farther to the south than that so designated by Hellyer in 1829.

Many place names on the coast of south-east Tasmania are the result of famous French expeditions, those of Bruni D'Entrecasteaux in 1792 and 1793 when Huon Kermandec was second in command, and that of Baudin in 1802.

Colonel Paterson named Launceston and the River Tamar in honour of Governor King who was born at Launceston, England, and the high mountain clearly visible from Launceston he, as a good Scot, named Ben Lomond.

To Governor Macquarie, who visited the island in 1811 and 1821, we owe names such as Lachlan, Macquarie, Elizabeth, Campbell, wherever found. The latter two in honour of his wife. To him, also, we owe the names Sorell, Perth, Oatlands, and Corra Lynn, to mention only a few. He also gave the appropriate name of Mt. Nelson to the marine signal station at Hobart. Governor Sorell who had served in the Peninsular War bestowed on the mountain which forms such a magnificent background for Hobart the name of Mt. Wellington.

Mt. Roland a prominent mountain in the north of the island affords an interesting example of the way a name is altered by the carelessness of mapmakers. In 1824 Captain Rolland an officer of the regiment stationed here determined to make his way from the coast near Port Sorell and ascend the mountain. After enduring hardships and encountering difficulties which nearly cost him his life, he was forced to return, defeated. From this circumstance the significant name Rolland's Repulse was bestowed. Under the misguided hands of cartographists, first the word Repulse was changed to mountain and later an '1' was dropped.

Explorers, such as Kelly, Frankland, and Gould have given us many names. To Kelly we owe Port Davey, Sarah Island (in honour of Mrs. Birch, wife of Thomas Birch, merchant of Hobart, who backed Kelly), and the Gordon River (in honour of James Gordon, of Pittwater, who lent Kelly the whaleboat for his voyage). To Frankland the classic names of Olympus, Ida, Pelion, as well as Lake St. Clair, Manfred, Cuvier, Petrarch. To Gould Sedgwick, Lyell, Owen, Huxley, and Jukes.

Many of the names of the features of the N.W. Coast we owe to the V.D.L. Co.'s officers. Among them are Mersey, Forth, Emu, St. Valentine's Peak, Cradle Mt., and Barn Bluff.

In later years recourse has been had to native names, some of which are quite appropriate. Of these Conara (black), Emita (sand), Parattah (frost), Powranna (a snake), Waddamana (a large river) may be mentioned; but others such as Marrawah (one), Moorina (indolent), Narrawa (yes), Kaoota (dusk), Magra (a day) have no significance.

25TH NOVEMBER, 1942

A meeting was held in the Society's Room on this date to celebrate the Tercentenary of the Discovery of Tasmania by Abel Janzoon Tasman. The President, His Excellency the Governor, presided.

The following papers were laid on the table, and taken as read:—

1. Early Town Planning in Hobart, by Dr. C. Craig.
2. On some new Hadrotarsidae (Araneae) with Notes on their Internal Anatomy, by Dr. V. V. Hickman.
3. Studies in Tasmanian Plants: I. Variation in Pultenaea juniperina, by Miss W. M. Curtis.

After introductory remarks by His Excellency, in which he drew attention to the importance of the occasion, Dr. W. L. Crowther gave an illustrated lecture on Abel Janzoon Tasman, of which the following is an abstract:—

> In this address, the background to the life and exploits of Abel Janzoon Tasman was briefly reviewed and stress was laid on the important part played by the Spanish and Portuguese in the discovery and opening up of the new worlds of America and the East Indies and the steady rise of Holland as a great sea power.
>
> Attention was called to the coincident unfolding of the great maritime development of England and its association with such navigators as Francis Drake in the America's and Middleton in the East Indies.
>
> Here a fitting tribute was paid to the historical work done for this Society towards the end of last century by James Backhouse Walker; his most important contribution being a description of the career and discoveries of Tasman, especially in relation to Tasmania. This monograph with the great work of S. Heeres has been the source from which local historians have hitherto drawn. To illustrate this address, pictures of areas of the Tasmanian coast associated with Tasman's expedition were shown, as well as maps, etc.
>
> In conclusion, it was stated that, owing to world conditions, it had not been practicable to systematically examine new material relating to Tasman's landfall, anchorage, and landings. Such sources included Huydecooper's Journal and his maps of Visscher, both that of Tasmania and his general map showing the day-by-day course of his ships. Gilsemans' map and R. Posthumus Meyojes work on Tasman and Visscher were also mentioned as throwing new light on Tasman's landfall and the watering place at Blackman's Bay.
>
> Finally the decision of the Tasmanian Government to re-name Green Island 'Visscher's Island', was welcomed, and the hope expressed that, to celebrate the Centenary of the Royal Society, research on Tasman's discovery to be undertaken by a qualified historian.

Mr. W. H. Hudspeth read a note on a chart by Gilsemans, Supercargo and Draughtsman on the 'Zeehan', a copy of which has recently been acquired by the Mitchell Library, Sydney.

Dr. J. A. Boot, formerly Netherlands Consul in Tasmania, then gave an address dealing with the background of Tasman's early life and with his discoveries.

The following gentlemen gave short talks on the subject of Tasman's discovery of Tasmania:—Mr. H. Allport, Mr. A. L. Meston, Mr. W. N. Hurst, Mr. E. T. Emmett, and Mr. H. O'May.

Afterwards a conversazione was held in the Art Gallery, when coffee was served

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Northern Branch

Annual Report, 1942

Meetings of the 1942 Session, other than the Annual Meeting and Public Lecture, were held in the Lecture Room at the Queen Victoria Museum and Art Gallery.

18TH MAY, 1942

Annual Report and Public Lecture

The Annual Meeting for 1942 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1942:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Mr. W. R. Rolph, Mr. V. D. Allen, Mr. G. McKinlay, Hon. Tasman Shields, Mr. J. R. Forward, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon Auditor: Mr. J. R. Forward.

The Annual Report and the Statement of Accounts, which showed a credit balance of £31 18s. 10d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a Public Lecture 'A Naturalist with a Cine-Colour Camera in Tasmania', by Mr. H. J. King. The lecture was given in the Public Library Hall, there being an attendance estimated at about two hundred and thirty.

The most important section of the films formed a continuation of the series of Nature-study films made by Mr. King in connexion with the educational programme of the Museum, and a series of bird studies was of particular interest. An interesting section of the film showed the development of the Common Fowl, and before this was screened the Honorary Secretary gave a short account of the various embryological phases of the Common Fowl, which he illustrated by means of a rough model in clay.

Mr. King alternated his series of natural history films with films of Tasmanian scenery.

8TH JUNE, 1942

The President, Mr. F. Smithies, presided.

Mr. G. P. Whitley gave an illustrated lecture on 'Sharks' (see p. 166).

20TH JULY, 1942

The President, Mr. F. Smithies, presided.

Dr. R. A. Scott, of the Department of Agriculture, gave a lecture on 'Tasmanian Potato Problems'.

Dr. Scott pointed out that, though to a layman the question of growing potatoes for food might seem a relatively simple problem, actually the subject is a very complex one, and problems raised in connexion with it involved several distinct departments of Science.

The speaker first discussed the problem of potato diseases. Different types of diseases were specified, and a distinction drawn between those more intimately involved with the organism, and those that were more or less incidental characteristics of the environment. This distinction led to a brief consideration of the modern Russian experiment of growing potatoes from seed.

The main part of Dr. Scott's address was devoted to a consideration of the problem of what constitutes quality in a potato, and to an account of methods adopted in an attempt to find measurable factors determining, wholly or largely, the apparent rather elusive characteristic of quality. A brief historical survey of work along these lines was given, with particular reference to the outstanding results of the Edinburgh School of Investigators.

Attention was called to the differing starch content of various varieties of potato, and to the character of the starch content curve, plotted against time, in the case of the individual tuber. This section of the address was illustrated by a practical demonstration of specific gravity, as used by Dr. Scott in his own researches.

The address was followed by a general discussion, in the course of which Dr. Scott, in answer to inquiries, gave some most interesting information.

31st August, 1942

The President, Mr. F. Smithies, presided.

Mr. P. H. Bond gave a lecture on 'Synthetic Rubber'.

Mr. Bond commenced by stating that Natural Rubber was first obtained in the Americas, and was known as Para Rubber. It was a monopoly of American interests. Rubber seeds were then taken to the East Indies and Malaya, which became the chief rubber producing centres, but over-production resulted, and prices fell below economic level; however, after the last war prices were stabilised. There are other sources of natural rubber besides the rubber tree, for example, the Russian Dandelion, Morton Bay Fig (related to the rubber tree), and other starch-producing plants.

Synthetic rubber did not exist as such, being incapable of synthesis, so that a better name would be artificial rubber. There are three hundred and thirty-three processes for making rubber, but only three so far were successful for making large quantities, namely the Buna, Neoprene, and Butyl. During the present war, America has been producing practically the whole of the Allies' supply of artificial rubber.

The only way in which Tasmania could produce rubber would be by the Neoprene process; all the material required for such an industry is available locally and is plentiful.

Mr. Bond concluded his address by observing that the day will come when synthetic rubber would play a bigger part in industry, and after the war it would outdo natural rubber.

The lecture was followed by a discussion, in which several members participated.

Council Meetings

Council Meetings were held on the 24th April, 18th May, 26th June, and 7th September.

NATIONAL MUSEUM OF VICTORIA

H. H. Pimblett, Government Printer, Tasmania.

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